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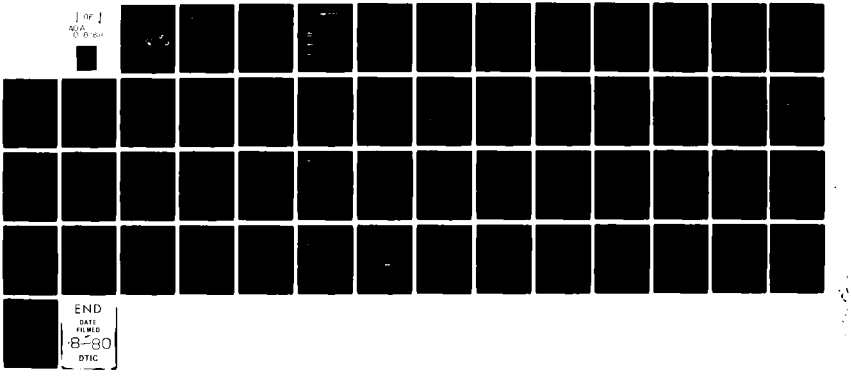

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This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and occasionally articles are prepared by, or in cooperation with, members of the

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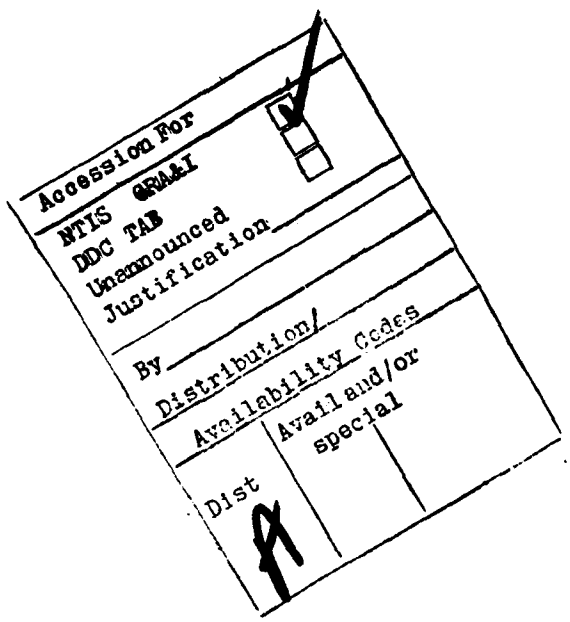

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NEWS & NOTES

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CLIMATOLOGY

BRRR—ENGLAND'S COLD WINTER OF 1978-79

The climate of England is always a good topic for study and discussion, for a great many reasons. The winter of 1978-79 was a relatively severe one. From 28 December 1978, there was intermittent snowfall for over four months. We last observed it on Election Day, 3 May, when Mrs. Thatcher was elected Prime Minister (this probably had nothing to do with the weather). Newspapers carried detailed accounts of the severe storms and accompanying hardships, and one headline read "The Grim Dawn of the New Ice Age."

The intense interest of the scientific community was shown by the fact that 250 persons attended a half day post-mortem, "Discussion Meeting on the Severe Winter of 1978/79 in Great Britain" on 16 January 1980. The meeting was sponsored by the Royal Meteorological Society.

Mr. R.N. Hardy (UK Meteorological Office, Bracknell) compared the winter of 1978-79 to other severe winters in the last century. First, he pointed out that no indices of severity are infallible because each severe winter has its own individual characteristics. Although some newspaper headlines had called the winter of 1978-79 the worst in 100 years, Hardy did not agree. He and some of the other speakers used the term "return cycle" or "return period" as a measure of comparison. This is defined as the interval of time taken for a parameter to return to some assigned value, usually an extreme value, for example, "the return period" of flooding in a river. The index he used for ranking or comparing severe winters was the number of days with air temperature below 0°C at noon and the total amount of precipitation that fell on these days. The winter of 1978-79 was very cold, but not very wet (although the snow stayed on the ground for a long period the total precipitation was a little below average) and its return cycle was of the order of 20 to 30 years. Comparable winters had occurred in 1917, 1940, 1947, and 1963.

Hardy pointed out that clement, warm winters occur in England when the Icelandic low pressure area is well developed and strong westerly winds prevail across England. He defined them as "mobile" winters. On the other hand, severe winters occur over England when the westerlies break down and storm centers travel either well north or well south of England. Under these circumstances the Icelandic low pressure area moves west of its normal position and is weaker than normal. The prevailing wind over England swings around to easterly directions. During the winter of 1978-79 there was an almost stationary high pressure area north of Scotland and there was a low pressure area south of England. This resulted in strong winds from the ESE which were sustained from mid-December until spring. One interesting point brought out was that there is usually no coherence in the pattern of severe winters in the northern hemisphere. That is, while there was a severe winter over England in 1978-79, the winter was not so bad over western Canada and Alaska. While England had less than the average amount of precipitation during the winter of 1978-79, the resulting snow and ice did not melt for a long time. For example, the Oxford area had a continuous snow cover for 65 days, 250% of the average duration during recent years.

Transportation in a number of cities in the UK came to a complete standstill because of the snow. The bad effects of the very cold weather were compounded by the wet, cold spring that followed.

Mr. C.V. Smith (UK Meteorological Office) gave a number of hydrometeorological statistics for the 1978-79 winter. Many of the reporting stations recorded four times the median in both the number of days that snow fell and the number of days with snow on the ground. The precipitation pattern was strange. For England and Wales as a whole, it was 204% of the median in December, about average in January and February, and 222% of the median during March.

Smith presented contoured charts of the return period for days when snow fell and days with snow on the ground. In both cases the return period was 10-25 years over much of England and Wales but jumped up to 50 years in some of the mountainous regions. He presented the same type of chart for depth of snow (this is not a very reliable statistic). The return period was 5-10 years over much of southeast England but increased to 200 years over some parts of the country.

Smith's comforting conclusion was that the severe winter of 1978-79 was not an indication of an overall cooling trend in the climate of the United Kingdom. He observed that careful studies of what appear to be climatic changes at certain weather reporting stations can often be traced to changes in instru-

mentation or changes in the location of instruments, or coincide with changes in observers.

Dr. D.G. Tout (School of Geography, Univ. of Manchester) gave a talk on the human biometeorology of the winter of 1978-79. He spoke on both the physiological and psychological effects of the weather. The combination of a very pleasant, warm autumn, a very cold winter, and a cool, wet spring had not occurred in England during at least the last 500 years and possibly for as long as 1,000 years.

Statistics on deaths from hypothermia in the aged rose from 90 in December 1978 to about 200 in January 1979 and 200 again in February. Total deaths from all causes showed a big peak over normal in January 1979. There is a strong correlation between ischemic (localized tissue anaemia due to obstruction of the inflow of arterial blood) heart disease in the aged, and cold weather. For 12 of the 14 weeks of cold weather, deaths from ischemic heart disease in the United Kingdom were greater in 1978-79 than the five year mean. Deaths from strokes peaked well above average in January 1979 as did the incidence of pneumonia. Deaths directly attributable to cold weather (not disease) totalled 88, while automobile accidents in January 1979 were one third above normal.

One strange statistic was that the number of common colds reported by medical doctors dropped dramatically during January 1979. One possible explanation was that people with colds simply did not brave the cold to visit their doctors.

The disastrous effects of climatic events on agriculture in the United Kingdom in the past have been well documented (*ESN* 33-12:503). Mr. E.S. Carter, Director of the UK Agricultural Advisory Service gave an interesting talk on the effects of the severe winter of 1978-79 on farm crops and animals. The essence of his talk was that while some crops and animals were damaged by the cold weather, the bad winter was not the disaster that might have been expected in the past. New and improved strains of cereal grains, notably barley, wintered reasonably well under the protecting snow cover. Crop growth in the spring, and all spring plantings, were delayed by the cool, wet weather. However, the lateness of the crop was partially compensated for by the fact that modern combines can harvest crops much later in the fall than was possible in the past. Sugar beets that had been left in the ground or improperly stored were ruined, as were members of the cabbage family that had been left out for harvesting during the winter.

Feed and forage for livestock became scarce, expensive and difficult to move. The worst damage was to sheep in the hilly areas of Wales and Scotland. Because grass was covered by deep snow for most of the winter, the ewes did not have enough forage. Some early winter lambs were lost in the cold, while others did not develop well due to the fact that the ewes did not have enough milk. Carter brought out the ironic fact that the European Common Market subsidized the British lamb crop to compensate for the hard weather. This also increased the income of the lowland sheep farmers whose lambs had not been badly damaged. According to Carter, the lowland farmers "had trouble driving all their Rolls Royces home."

The final scheduled speaker was Dr. D.M. Houghton (UK Meteorological Office). He discussed the possibility of forecasting severe winters in the UK. First, he debunked all ideas of weather repeating itself in cycles. He showed a slide of part of a weather record that indicated a clear cyclic nature for a number of years. Then he showed more of the record wherein the cycles disappeared. A number of researchers have related changes in weather parameters to changes in sunspots. Houghton ruled out any factor exterior to the earth as the cause of severe winter weather in the UK because of the lack of coherence of severe winters around the northern hemisphere. After examining a number of possible causes of severe winters in mid-latitude, Houghton ruled out most, except for large-scale sea surface temperature anomalies (SSTA). He stated that "while the whole answer is not here yet, there are hints that SSTA's may be the answer." He also discussed SSTA-weather anomaly research programs in the US. Houghton is presently using a large computer to look at correlations between winter weather in the UK and 42 million sea surface temperatures that have been recorded during the past century.

As I have noted in previous reports, there was a good deal more discussion and response from the audience than I am used to in the US. Many students, showing healthy skepticism, took part in the discussions. (Wayne V. Burt)

COMMUNICATIONS

APPLETON LAB LOOKS TO THE FUTURE

In February 1979, the UK Science Research Council (SRC) confirmed a study committee's recommendation to close down the Appleton Laboratory facility at Ditton Park, Slough, and, while retaining the Appleton name, to merge that laboratory's operation, in both a geographical and functional sense, with those of SRC's Rutherford Laboratory at Chilton. Chilton is about 40 miles farther west of London than is Slough (see *ESN* 32-11:400). During my visit to Slough, almost exactly one year after that pronouncement, the trauma that had been induced within the organization was quite apparent, but there also existed both a healthy sense of ongoing work and continued planning for future activities.

The trauma was expressed in both personal and historic scientific terms. In a historical context, it was made quite clear, as we walked aroung the complex at Ditton Park, that we were "...treading on hallowed ground." This was conveyed by a wave of the hand toward a shack where (Sir Robert) Watson-Watt "... had done his figures" leading to his notable developments in the passive radio-direction-finding and the radar systems fields and, through a comment in passing, that Appleton was "... where the ionosphere was invented," a reference to Oliver Heaviside's work in 1902 (when he and the American, Arthur Kennelly, had explained the results Marconi had achieved the previous year in the first successful transatlantic radio signalling experiment). I have not checked on the analogous scientific holiness of Chilton's grounds.

The movement of facilities and personnel from Slough to Chilton had started the previous month; that phase of the transfer is expected to last for at least a year. During the transition period, a number of activities will continue at Slough in support of work which is now going on or is expected to be going on at or near the new location.

One such activity is the research related to tropospheric propagation of millimeter-wave (mm-wave) radio signals. The subject is of significant interest to those involved in planning and operating ground-to-ground, ground-to-air and ground-to-space links in communications, radar, radio astronomy and atmospheric-pollutant measurement systems. This activity is carried out under the direction of Dr. J.A. Lane. A set of complementary approaches is used at Appleton in this research effort: measurement of energy absorption in a very tightly-controlled laboratory environment, and measurements of a more general, systems-oriented set of parameters (signal distortion, signal-to-noise ratio, bit-error rate, plane depolarization, etc.) performed on an outdoor test range.

The laboratory-environment studies of mm-wave gaseous absorption have been carried on at Slough and will continue to be done there for a few more months. The principal tool used in these studies is a set of reverberant, untuned cavities within which atomspheric-like gas mixtures of controllable concentrations are contained. These cavities can be used to simulate linear-transmission path lengths many times greater than the cavity's physical dimensions. Within the cavity, pressure and temperature are closely controlled. The largest such cavity at Slough simulates a 100-meter-long path in a cylindrical box about 1 meter in diameter and 2 meters long. This cavity has been operated through and beyond the mm-wave band up to a frequency of 1 THz (1000 GHz). Dr. D. Llewellyn-Jones commented that increased sensitivity and accuracy for such measurements will be possible in the future when an even larger cavity, which is presently being installed and checked out at Chilton, is ready for full-time operation. Its linear dimensions are only approximately twice those of the largest cavity at Slough but, since special care was taken to provide a low-loss surface characteristic, it has been shown, in preliminary measurements which were made at 60 GHz, to simulate a path length of 650 meters. This is the largest known cavity of its type.

With respect to the mm-wave test range (MTR) facilities, Dr. J.R. Norbury has designed and begun to operate a computer-controlled, short-range (270-meter long) link at Slough. The experience gained with the hardware, software, and analysis techniques being developed on this installation will be applied to the operation of a permanent test range presently being built in the west, closer to Chilton. That permanent facility will include three instrumented paths, all converging at a receiver/control facility located at the site of the Chilbolton Observatory. Those paths are 0.5 km, 3 km, and 20 km long, respectively.

The experimental link at Slough has been operated under computer control at 37,57,97, and 210 GHz in the mm-wave band, together with an infrared (10 μm) and a helium-neon laser link to provide qualitative comparisons. The permanent MTR will be designed to operate initially from 20 through 210 GHz (except for the 20 km path which will operate up to 110 GHz), with capability to expand coverage to 300 GHz as suitable equipment becomes available.

Since atmospheric characteristics along the transmission path are the primary uncontrolled parameters in these experiments (effects of vegetation growth and other obstructions being of secondary importance at this time), a set of small meteorological test stations were designed to provide the pertinent data. One type measures "instantaneous" rainfall rate, temperature, and humidity; the other measures atmospheric pressure, raindrop-size distribution, and the wind's speed and direction. The first type will be located at 100-meter intervals along the 0.5 km path, with meteorological instrumentation for the other paths yet to be determined; the second type will probably be located only near the terminals. Both types have already been installed at the experimental link at Slough.

The overall experimental system at Slough was still being shaken down while I was there; therefore the stability of the transmitters, characteristics of the antennas and their rotatable pedestals, ground-clearance effects, receiver subsystems, modulation methods, data-handling algorithms and control-system hardware and software had yet to be fully evaluated. Dr. Norbury and his co-workers look forward to later in the 1980s, when this experience has evolved into a permanent MTR facility which can be used simultaneously by qualified academic, government, or industrial researchers for basic propagation research, communication system design, and component or subsystem evaluation. The simultaneity will be provided through incorporation of the MTR capabilities within the computer-controlled multiple transmitter, antenna and data handling subsystems.

The tropospheric propagation studies discussed constitute only about 20% of Appleton's present activities. About two-thirds of their efforts deal with the project management and support of the UK's space-satellite and upper-atmosphere balloon projects, about 10% deal with ionospheric propagation research (lately, the study of high-frequency radio-wave backscatter from the sea) and the rest involve planning new fields for the scientists at Appleton Laboratory to venture into. With the example of the constructive efforts toward a smooth transition from Slough to Chilton displayed by the tropospheric propagation research group, we can hope for a future hallowing of Chilton's grounds. (Philip Fire)

ELECTRONICS

ALLEN CLARK RESEARCH CENTRE—PLESSEY RESEARCH

The Allen Clark Research Centre of the Plessey Company Ltd. is located at Caswell, Northampton near Towcester (pronounced toaster) about 60 miles northwest of London. There is no town of Caswell, only some farm buildings which, along with newer buildings, are now occupied by offices and laboratories. Caswell is not accessible by train and, in fact, neither is Towcester. Therefore we travelled to Caswell in a London taxi owned by one of the authors (RSH).

First, we met our hosts: Drs. J. Bass, the director, and G. Gibbons, head of the Optoelectronics and Microwave Division. They told us that Mr. Allen Clark founded Plessey in 1920 for the purpose of manufacturing radio broadcasting parts. Since then, Plessey has grown into a holding company for the following divisions: Plessey Electronics Systems, Plessey Telecommunications, Plessey Solid State Division, Plessey Aerospace, and Plessey, Inc., which is the US division. The Clark family is still intimately concerned with Plessey; Sir John Clark is chairman of the board and Mr. Michael Clark is president. Last year the company's business volume had a value of £700 M in the UK and £100 M in the US.

The Allen Clark Research Centre is the corporate research center and is responsible directly to the board of Plessey Company Ltd. The center is divided into three main divisions, Integrated Circuits, Optoelectronics and Microwave, and Transducers and Electronic Materials, plus a number of support divisions.

Total funding of the research center is about £8 to 9 M annually. This is obtained principally from out-

side agencies in the following approximate percentages: the Ministry of Defence (55%), other Plessey Divisions (30%), and the British Post Office (10%) Some research funds (5%) are also available from within the corporation for use as seed money to initiate new projects

Interaction with academia takes place in the usual ways: through consultants, and the placing of some research work in university departments. The center also supports studentships (study grants) for workers and helps support graduate students with CASE awards (Cooperative Awards in Science and Engineering). These CASE awards allow graduate students to utilize their work at the center to meet part of the requirement for an advanced degree. With 250 professionals in the total work force of 500, the age distribution curve at the center has a relatively strong peak at approximately 31 years. This contrasts with many American laboratories where the age peak comes later and is relatively small. The Plessey distribution is evidence of the relatively high mobility of professionals in their middle years. Often these people develop a new technology at the center and then follow the technology when it moves to a manufacturing division. Plessey Optoelectronics and Microwaves Ltd. (POML), located at Towcester, is a good example of this. Approximately half of the present staff of 180 has been drawn from the research center at Caswell.

With the exception of the comments about the IC Division, the remainder of this report covers only the Optoelectronics and Microwave Division (OMD). The information on both the IC Division and the OMD was obtained either during the briefing given to us by G. Gibbons or from discussions with investigators within OMD. Among the recent, more interesting, advances in these two divisions are the production of 14 GHz gallium-arsenide, field-effect transistors (GaAsFETs) with a noise figure better than 2 db; the development of monolithic microcircuits on gallium arsenide; and a technique for optically writing and erasing planar-optical-waveguide components. The last-named technique, which has been made possible by the use of organic photochromic materials of the class known as fulgimides, is discussed in more detail below.

The Optics Department is the largest of four in the OMD. This department has 60 investigator/support personnel and is comprised of 3 groups: Fiber Physics and Integrated Optics, Sources (for fiber optics), and Detectors. A discussion of some of the Optics Department's projects follows.

In the UK, as in the US, the Bragg-cell spectrum analyzer is the first integrated optics device for which significant R&D support is being provided. The objective of the UK effort is to develop an rf spectrum analyzer that has 1000 channels, a bandwidth of 1 GHz, and a dynamic range of 50 db. The analyzer's three key components are acoustooptic Bragg deflectors, lenses, and charge-coupled device array (CCD) detectors. In this device, an rf signal, fed to the deflectors, causes a narrow beam of light to be deflected so that the light is incident upon one of the detectors of an array. The deflection angle is a function of the frequency of the rf signal, and therefore the output signal from specific detectors corresponds to specific input frequencies. Currently, a 3-man-year effort in the Fiber Physics and Integrated Optics Group, under W. Stewart, is directed toward developing The Bragg-cell portion of the spectrum analyzer. (Standard Telecommunication Laboratories Ltd., Harlow, is also working on Bragg-cell development.) The lens portion is being addressed at both University College, London, and the University of Glasgow; at present, nobody is working on the CCD problem. Plessey's involvement in this 3-year program commenced in mid 1979; their basic approach involves the use of a number of beam-steering arrays (3 or 4) on $LiNbO_3$. The arrays will be produced by e-beam lithography. Since the coupling of light into the guiding layer will be required in order to evaluate the deflection efficiency, etc., of these arrays, one of the more commonly used coupling techniques will also be implemented at the center. This effort is being supported by both MOD and the European Space Agency.

For some time, investigators at the Allen Clark Research Centre have been working on optical memories, and considerable progress has been realized toward the development of both read-only and reversible holographic memories. R.J. Hurditch, a member of Stewart's group, said that work on holographic data storage systems ceased some 9 months ago, and that the current emphasis is on photochromic materials, also to be used for optical memories. Photochromics, of which self-darkening

sunglasses are a well-known example, are materials that exhibit a reversible change in absorption spectra. This change is induced, in at least one direction, by the absorption of light, usually in the blue/uv portion of the spectrum.

In a collaborative effort between Plessey and Prof. Heller of the Edward Davies Chemical Laboratories, University College of Wales, Aberystwyth, a series of truly unique photochromics has been developed. These organic materials, called fulgimides, are described in a number of UK patents and in US patent No. 4,145,536 (1979). The absence of spontaneous thermal reversal from the colored to the uncolored state in these photochromics leads to high thermal stability, with colored state lifetimes at 25°C estimated to be many tens of years. These materials exhibit a high sensitivity for bleaching (writing) between 480 and 520 nm and thus high data rates should be obtainable through use of the strong 488 and 514 nm emission lines of the argon ion laser. The high coloring sensitivity in the 330 to 410 nm range in these materials means that rapid erasure can be realized with the use of argon or krypton uv-emission lines. As a result of the discrete molecular nature of the photoinduced structural (spectral) changes, the photochromics have a resolution capability higher than that of any conventional film. With the general trend toward disc technology in both the memory and entertainment businesses, Plessey may develop a photochromic disc in the near future.

The change in refractive index that is associated with a change in absorption is sufficiently large in these photochromics to provide for optically written and erased planar waveguide components. In a new effort, waveguide patterns have been generated by projecting the desired pattern in green light (bleaching) onto the surface of a previously colored sample using the corresponding negative pattern. The use of this technique, or a variant of it, to produce components such as beam splitters, reflectors, filters and lenses, is under study. Early results of this work should appear in the literature soon.

Stewart's group is also involved in optical fiber assessment and the development of connectors and power splitters for these fibers.

The Sources Group, led by R. Davis, is working on surface-emitting, high-brightness, light-emitting diodes (LEDs) operating at 0.9 μm (GaAs), 0.82 μm (GaAlAs), and 1.3 to 1.6 μm (GaInAsP). Three aspects of these sources are unique: (1) High-power combined with good reliability (sources have been operating since May 1974 [J 40 kHrs]); (2) Spherical lens coupling to an output fiber pigtail, with which an 18-fold improvement in device efficiency has been demonstrated; and (3) A novel method for hermetic sealing. Under US Air Force sponsorship, Plessey has just completed a program in which fully hermetically sealed (fiber/can), high-radiance LEDs were produced.

Since 1975 members of Davis's group have been investigating the use of microlenses for increasing the coupling efficiency between LEDs and fibers. Recently they have published reports on the use of both hybrid and integrated lenses/sources. In the former case, a 100 μm truncated titania-silica lens (with the truncated surface cemented to a surface emitting [at 1.3 μm] GaInAsP/InP LED) was used to couple the emission into an 85 μm step-index silica fiber. Gains in coupling efficiency over the butt-coupled case exceeded a factor of 12 for small-area devices. The experimental and analytical details of this work (including discussions of coupling and frequency response theory) are presented in *IEEE Trans. on Elect. Devices*, ED-26 1215 (1979). Recent results of their integrated lens/source study appeared in *Elect. Lett.*, 16 14 (1980). In this paper a calculation of the coupling efficiency is presented for a GaAs LED with a hemispherical lens fabricated on its surface. The lens and fiber core were of equal diameter (85 μm). For the case of a constant junction temperature and a disc-shaped source (where the thermal impedance varies as 1/r with r being the disc radius), a maximum occurs in the coupled power for a source radius of 2 to 3 μm.

The Sources Group is also working on a monolithic optoelectronics project in which the objective is to integrate field effect transistors, detectors, LEDs, and passive components in both GaAlAs/GaAs and GaInAsP/InP.

Lead-tin-telluride detector (10 μm) development is one of the successes of A. Mabbitt's Detectors Group; this detector is now a part of POML's product line. In addition to working on GaInAs PIN diodes for use at 1.3 μm and at 2.06 μm for "eye-safe" holmium laser rangefinders, they are developing devices based on amorphous silicon (a-Si) and amorphous silicon carbide (a-SiC).

Among the a-Si devices are zener diodes and hydrogenated solar cells produced by the rf glow-discharge technique (*ESN* 34-4:203). Also under development are a-SiC LED alpha numeric displays, In addition this group is conducting a long-range research effort on extrinsic Si which will ultimately be used for detectors in the 3-5 μm band.

The Materials Department of OMD is headed by M. Cardwell and the principal effort of this group of 30 is research on epitaxial growth and ion implantation of III-V compounds. (Substrate materials used are commercially available GaAs and InP.) At Plessey, there are presently 2 hydride reactors, 3 metallo-organic reactors, 3 reactors for performing liquid-phase epitaxial growth (LPE), and 12 that utilize the vapor-chloride process. There is currently no molecular beam epitaxy work at the research center.

An example of work just completed within the Materials Department is a Boltzmann equation study of the influence of chromium (Cr) on the mobility of electrons in GaAsFETs, by B.T. Debney and P.R. Jay. They concluded that the poor mobility profiles found for some device layers grown on Cr-doped GaAs substrates are consistent with an out-diffusion of Cr from the substrate into the epitaxial layers. On the experimental side, M.C. Hales has completed an effort to determine the limitations on epitaxial deposition of InP using a horizonal chloride vapor-phase reactor. His results led him to conclude that, for fastest growth rate, the flow rate and mole fraction over the source should be high, while for most efficient and reproducible growth, low flow rate and mole fraction are more desirable.

The GaAsFET Department of OMD, headed by J. Turner and comprised of 40 individuals, is developing devices for use in low-noise microwave amplifiers for S and X bands, broad-band amplifiers (10-20 GHz), and high-power amplifiers (S and X bands and 30 GHz). Fabrication of these devices requires gates as narrow as 0.3 μm in the GaAsFETs and is accomplished with the use of electron-beam-lithography (EBL) techniques. (The research center has two EBL machines.) Gibbons pointed out that while there is a military market for GaAsFETs, the real potential for high volume lies in their use for direct pick-up of TV signals from satellites by home receivers, a concept presently under serious consideration in Europe.

The other effort in the GaAsFET Department aiming at mass markets deals with GaAs digital circuits. So far, Plessey has made only individual circuits; the aim, of course, is toward mass produced ICs.

The Microwave Diode Department of OMD, headed by F. Myers, performs research and development on Gunn devices (GaAs and InP) and IMPATTs (Si and GaAs). The three principal efforts here are (1) The development of pulsed InP sources for frequencies below 20 GHz, (2) Si IMPATTs for pulsed and continous operation (cw) and cw InP Gunn devices (e.g., local oscillators) for the mm wave ranges (up to 150 GHz), and (3) GaAs IMPATTs for KU band (12.4-18 GHz). Achievements quoted were 800 mW with 12% efficiency at 50 GHz; 40 mW with 7% efficiency at 140 GHz, and 2 watts in mid-Ku with an efficiency of 20%.

For a number of years, the Transducers and Electronic Materials Department (TEM), headed by F. Ainger, has been engaged in the development of piezoelectric and pyroelectric materials. The electric polarization (dipole moment/volume) of these materials changes in response to a change in pressure or temperature. The materials are used, variously, in surface acoustic wave technology (for signal processing); for detection or imaging of ir radiation; for the development of improved microphones (e.g., for replacing the carbon microphone in a telephone); and for their electrooptic properties.

We were able to talk briefly to R. Whatmore of TEM, who has been engaged in the development of pyroelectric ir detectors. At present, such detectors find their greatest application in intruder alarms, but they are also of interest for other sensing applications and for imaging. While pyroelectrics are only one-tenth as sensitive as semiconductor detectors (e.g., Pb Sn_{1-x} Te_x) they have the advantages of being relatively cheap and of operating at room temperature. Whatmore talked of a hot pressed pyroelectric, composed of $PbTiO_3/PbZrO_3/PbFe_{\frac{1}{2}}$ $Nb_{\frac{1}{2}}O_3$ and doped with uranium oxide, which is used to reduce the dielectric constant from 350 to 250 and to minimize the dielectric loss at low frequencies. (In general, to ensure the high sensitivity of pyroelectric devices, it is desirable to have as low a dielectric constant as possible.) To prepare this material as

an ir detector, it is first hot pressed, then it is sliced, electroded, poled in an oil bath at 150°C under an applied field of 3/kV/mm for 15 minutes, and finally, it is mounted with an FET (to which it is connected through a resistor between source and gate electrodes) in a standard TO-5 can.

Whatmore also told of present work with other pyroelectric materials, i.e., the vapor-phase-grown boracites, which are also sensitive to 8-12 μm radiation. These materials, which have the chemical formula $M_3B_7O_{13}X$, where M is Fe, Ni, Mn, Cu, or Zn, and X is a halogen, are improper ferroelectrics with a high pyroelectric coefficient. They are much more robust than the well-known pyroelectric material TGS. Whatmore mentioned that other investigators of boracites are Prof. H. Schmid (Univ. of Geneva, Switzerland) and the group of W.A. Smith of Philips Laboratories (Briarcliff Manor, NY).

Plessey's IC Division is charged with developing technologies, with tasks that range from basic science to pilot-plant production. The pilot-plant facility, in fact, produces high-technology circuits in small quantities for special customers. According to Gibbons, the 80 IC designers at Plessey form the largest IC designer group in the world, and this group corresponds to about 2% of the world's IC designers.

Ambience at the research center is youngish. This is evidenced by the age distribution curve and obvious vigor and relish shown by those "Researchers in the Country." (R.S. Hughes, I. Kaufman, J.R. Neighbours)

ELECTRICAL ENGINEERING AT GREEK UNIVERSITIES

One of the most enthusiastic individuals whom I have had the pleasure of meeting recently is Prof. V. Makios of the University of Patras, with whom I became acquainted on a visit to Greece in October 1979. Almost as soon as we had completed formalities of introduction, Makios, in a most ardent manner, presented me with two pleas. First, he stated that he would like to aid in developing an electronics industry for Greece. He felt that, because of its geographic location, Greece would be an ideal place for US companies to establish branch organizations. Because of Greece's proximity to the Middle East and to Africa, a large number of markets could be served by such organizations. Makios was not thinking simply of establishing production units, but of engineering-oriented organizations. He felt that these could be very well staffed principally by Greek engineers who, according to Makios, have generally been outstanding students and who are receiving an excellent technical education in Greek universities. Second, Makios would like to place several of his students into American graduate programs every year. He asked me, therefore, to acquaint readers with the selection process used in admitting students into Greek universities and also to inform readers that students graduating from electrical engineering at the Univ. of Patras are very well prepared to enter graduate programs. Moreover, after graduate work in the US, such engineers could return to Greece to staff the branch companies he mentioned earlier.

The selection process mentioned requires university candidates to take competitive entrance examinations. Every year around 100,000 students take these, but only 15,000 are admitted into the universities.

There are presently 7 universities in Greece. The following 5 have schools of engineering: National Technical Univ. of Athens (NTU); Aristotelian Univ. of Thessaloniki; Univ. of Patras; Univ. of Thrace; and Univ. of Crete. I visited NTU and the Univ. of Patras and have been in contact with Thessaloniki. The Univ. of Thrace is quite new (1974), and the Univ. of Crete was established in 1978. All these institutions are supported by the state, and the professors are civil servants. However, although the Ministry of Education has fiscal responsibility, the universities are self-governing in internal affairs.

What is it like to be at a Greek university? According to my information from NTU, a course of studies takes 5 academic years. An academic year runs from 1 September to 30 June, and is followed by 2 months of vacation. Classes are held 5½ days a week. Attendance at lectures and tutorial sessions is compulsory for all students. The homework system is much like most such systems in the US, in that every student is required to prepare personally, and submit at the times specified by the professors, the reports, drawings, exercises, laboratory work, etc., that have been assigned. Examinations are given annually; promotions are based on the results of these examinations. Permission is granted to take these examinations

only if the annual progress grade, based on homework, etc., is at least 50%. After completing the final year, a student is permitted to take the "Diploma examinations." A student who passes these is granted the degree of Graduate Engineer as well as a professional license to practice the branch of engineering related to the degree.

During the last year of studies, each student is required to write a thesis on a subject within his field. The entire program is thus similar to a combined BS/MSE program in the US.

As is the case in most other countries in Europe, there are no formal graduate studies at NTU. However, the university does grant the degree of Doctor of Engineering (DE) following a period of doctoral research and upon acceptance of a thesis which proves that the candidate possesses the ability to carry out original scientific work. However, such Greek DEs seem to be in the minority, for I found a number of professors who had completed their graduate studies in the US. In fact, because of this US experience, there is presently a move to model the Greek educational system after that of the US. This includes the concept of credit hours, which does not exist in Greek universities to date.

Now to a report on my specific contacts: At NTU I talked at length with Prof. J. Tegopoulos and Prof. E.N. Protonotarios. Tegopoulos, who holds the chair in electrical machinery and whose office is in a large old machinery laboratory, is in his fourth term in the elected office of dean of electrical engineering (EE). He told me that EE presently has about 500 students, and that with the present conversion to computers everywhere there is no difficulty placing EE graduates into jobs. He said also that about 3 to 4% of the students in EE are women. Students pay no tuition and get their books free (but only graduate students get a support stipend), and his department is presently trying to organize graduate work and convert to a US-type system. Tegopoulos, who received his PhD from Purdue and then worked at Westinghouse in Pittsburgh for nine years, is presently performing theoretical work related to superconducting machines. He and a former graduate student, Prof. E.E. Kriezis of Thessaloniki, have worked on the penetration of eddy currents into conducting media and are presently writing a book on the subject.

Protonotarios, who received his PhD at Columbia University and also taught there, has worked at Bell Laboratories and now holds the chair of basic electrical engineering. Actually, his field is digital systems and information theory. He presently works on computer networks, i.e., methods of interconnecting computers and communicating by way of the packet switching idea. Protonotarios has done this type of work both for Olympic Airways and for the military services in Greece. He has also been writing papers dealing with communication in biosystems. He told me of his continuing connections with colleagues in the US and informed me that he is presently chairman of the "Greece Section" of IEEE.

In response to one of my questions, Protonotarios said there is adequate funding for instruments at NTU, but he also explained that it is difficult to hire people, because salaries are too low. Moreover, it takes months to complete the paperwork for hiring a person. In addition, there has recently been a change in the law that governs employment of instructors and those at lower staff level. Formerly these individuals were guaranteed employment almost from the time of employment until retirement age. A law recently enacted has changed the period of employment for them to a maximum of six years. The present period of transition from one law to the other is a bit trying.

According to Protonotarios, most EE professors perform research in addition to their teaching duties. The names of some other professors and their respective fields or chair designations follow: J.G. Fikioris, wireless and long distance communications; C. Halkias, electronics (Prof. Halkias is the co-author of a successful book on electronic circuits); T. Nikolopoulos, high-voltage engineering and measuring techniques; J.E. Diamessis, electrical networks and systems; Krikelis, control systems; Pappadias, power systems; C. Theofilopoulos; electromagnetic fields; M. Angelopoulos; production, transmission and distribution of electric power.

While NTU is situated in the middle of Athens, in buildings 50 to 100 years old, the Univ. of Patras is presently constructing buildings on a new campus in what is the most beautiful location for a university that I have seen. Patras itself, a city of about 100,000,

is located on northern edge of the Peloponnesus, about 125 miles west of Athens. The university is a few miles outside Patras, near the shore of the Gulf of Corinth, and near the village of Rion. There are mountains in the background, mountains across the Gulf of Corinth, blue sky, and sun! My conversations about electrical engineering at the Univ. of Patras were with Makios, mentioned earlier, and Prof. G. Papadopoulos.

As at NTU, the EE undergraduate program at the Univ. of Patras covers 5 years and includes a thesis project during the last year. Makios, who returned to Patras in 1975 after 10 years in Germany and 10 years in Canada (where he taught at Carleton Univ., Ottawa), holds the chair in electromagnetics. He told me that he maintains excellent relations with his former colleagues at Carleton, and this is manifested by a flow of graduate students from Patras to Carleton. As I mentioned earlier, Makios is trying to broaden this flow to other North American universities.

There are presently 35 students taking Makios's course in microwaves. His equipment and that of other laboratories that I saw at Patras were comparable in quality with that found in North American universities. It should be noted, though, that these laboratories are used principally for undergraduate instruction at this time.

Papadopoulos, who holds the chair in applied electronics, received his graduate degrees from MIT and taught at the Univ. of Massachusetts (Amherst, MA). He too, returned to Greece in 1975. His past work was in long baseline interferometry; now he specializes in computer applications. Papadopoulos told me, "With my background, I believe that I can judge students, and I think that we produce very good students here."

Other professors in EE at Patras are J. Nicholis, (antennas and propagation), G. Kokkinakis (telephony), A. Grammatikos (systems), and G. Galanos (power).

The enthusiasm at Patras is exemplified by the fact that during the past year this new university held four international conferences in the field of electrical engineering.

Regrettably, time did not permit me to visit Thessaloniki, the second largest city in Greece. This city, also known outside of Greece as Salonika, is on the Gulf of Salonika, an inlet of the Aegean Sea. Thessaloniki, which was founded in 315 BC, has a long history as a center of art and culture. The Univ. of Thessaloniki was founded in 1925. However, as at the Univ. of Patras, its EE program is only a few years old. According to Prof. E.E. Kriezis, who holds the chair in electromagnetic field theory, the main research activities in his department are performed by his group. Recent published papers deal with a spectrum of problems, from eddy currents in machines to transient-field distribution in a multilayer waveguide. In addition to such theoretical problems, the group is also interested in the study of the sea-state by means of radar and in creating a microelectronics laboratory. The sea-state work is to be done together with Prof. S. Kouris, also in EE. The microelectronics laboratory is to be developed by Dr. P. Hagouel, who brings with him a background in x-ray lithography from the University of California (Berkeley, CA). Readers active in probing the sea by radar or in microelectronics and interested in collaborating with a Greek university on these subjects are invited to contact Prof. Kriezis.

Based on the creation of the new universities and some of the enthusiasm that I saw during my visit, it is my impression that this small country of 9 million people will soon be making increased contributions to electrical engineering that will be a favorable reflection on its ancient heritage. (Irving Kaufman)

SOLID STATE ELECTRONICS IN ROME

Several years ago, while I was a guest at one of the laboratories of the Consiglio Nazionale delle Ricerche (CNR, the National Research Council of Italy), I observed that there seemed to be no mechanism for these laboratories to interact with industry. Obviously I was not in on the big picture, for, during a recent visit to the Laboratorio di Elettronica dello Stato Solido (LESS), the Laboratory for Solid State Electronics of CNR, I found out that in 1970 CNR established 3 laboratories that had the specific mission of interacting with industry. These are in Parma (electronics and magnetism), in Pisa (atomic physics and applications) and LESS, in Rome. This is a report on a visit to LESS, located on Via Cineto Romano 42, in the outskirts of Rome.

My genial and enthusiastic host was Prof. Antonio Paoletti, the director of the laboratory, who is also a

professor of physics at the Univ. of Rome. Before setting up LESS, Paoletti was director of the applied nuclear physics laboratory of the Nuclear Energy Committee of Italy (1966-69). Prior to that, he spent 3 years at Brookhaven National Laboratory (Upton, Long Island, NY), so his English is outstanding. His specialties are the magnetic properties of metals and insulators.

Though small, with a staff of only about 20 scientists and 20 technicians, LESS appeared to be full of enthusiasm and quite productive. As for its mission to establish connections with industry—according to Paoletti, this has been a difficult task, with only minor success. The reputation of industry in Italy to want to "do its own thing" seems to be well founded.

I felt rather honored that, shortly after my arrival at LESS, Paoletti assembled the leaders of his scientific groups in a small auditorium where they briefly discussed some of their research and the equipment used for carrying it out. The activities described fell into the categories of magnetic devices, materials, semiconductors, cryogenic devices, and diagnostics and technology, all with the principal emphasis on applied research.

Obviously, the ability of a laboratory to perform experimental research is based to a great degree on the equipment and techniques available. The next several paragraphs focus on these aspects of the laboratory.

For film deposition with appropriate thickness monitoring LESS possesses facilities for both electron gun evaporation and rf sputtering. Specialized equipment required for film growth by liquid phase epitaxy (LPE) has been in operation at the laboratory for a number of years, for growing magnetic garnets and materials for bubble memory and magneto-optic applications. Crystal growth has been carried out by the Czochralsky technique for Ge, Si, GaP, and other semiconductors; by growth from the flux for magnetic garnets and orthoferrites; and by sintering (magnetic materials). LESS has apparatus for measuring thickness and profile by the Tolansky technique (Fizeau multiple-beam interferometry) for the range 100 to 10,000 Å, by a stylus instrument for the range 30 Å to 100 μm, and by an interferometer for dielectric films for the range 1 to 100 μm. The laboratory also possesses equipment for x-ray diagnostics for both bulk materials and films down to 1 μm thick.

For optical diagnostics, LESS can perform measurements in the visible and near infrared regions of absorption, linear and circular dichroism from 0.3 to 5.0 μm, and complex refractive indices from 1 to 25 μm. Considerable equipment is also at hand for electronic/optical diagnostics, to measure such quantities as resistivity, DC and AC Hall effect, photoconductivity, noise, etc.

An X-band microwave spectrometer is available for performing the various measurements that are generally of interest for ferromagnetic resonance. The cryostatic work uses cryostats in the range 4 K to 300 K with stability better than 1 K, as well as cryogenic heads for temperature reduction to 0.8 K. In addition, there are the usual auxiliary laboratory facilities, as well as equipment for photoreduction and photolithography and for the various operations usually carried out in the treatment of crystals.

Now to a survey of work at LESS. By now we are all familiar with the use of light-emitting diodes (LEDs) and liquid crystals for alphanumeric displays. Magnetically activated displays are virtually unknown, however. Such a magneto-optic alphanumeric display was demonstrated to me by Prof. B. Antonini. This display uses a garnet film similar to the type used for magnetic bubbles, but with a room temperature magnetization low enough so that in zero-applied field the film does not exhibit the conventional stripe domain pattern. Magnetostatic forces acting on the domain walls then become comparable with the wall coercivity, and the domain structure has a very high remanence. Domains over a range of sizes can then be arbitrarily shaped, under external drive magnetic fields, to produce graphic symbols with the final configurations stable without any external fields. These symbols can be made visible by use of the Faraday effect, thus realizing an optical display whose character can be given colors ranging from yellow to blue. Switching times here are of the order of 100 μsec.

According to Antonini, this display work is an outgrowth of the work on garnets that came into being because of interest in magnetic bubbles. The laboratory originally studied magnetic bubble storage in orthoferrites obtained from Bell Laboratories. In 1974, when D. C. Borghesi joined LESS, the effort shifted to the growth of garnets and garnet films. An example of such work

is the growth and characterization of a magnetic garnet layer and the construction of a magnetic bubble shift register in recent joint projects with CSELT, a branch of the Italian telephone company.

In addition to work on the technology of bubble memory devices, there has been considerable research on the alteration of low temperature properties of magnetic materials by irradiation with light peaked in the near infrared. Typically, these materials are rare-earth garnets doped with group-IV elements. Among the properties that are altered are permeability, coercive force, and static anisotropy. In addition to the work on the physics of such "photomagnetic" garnet systems, LESS has developed new diagnostic techniques for the study of these materials.

Among the theoretical successes in the group was a model of the photoinduction process, with application to the explanation of magnetic circular dichoism. This resulted in joint and successful experimental work with Bell Telephone Laboratories, Murray Hill, NJ.

Another magnetic program has dealt with ferromagnetic resonance. An example was the demonstration that thick LPE-grown YIG films support magnetostatic waves propagating in the unpinned mode.

As summarized by Borghesi, among the scientific accomplishments of LESS in the magnetics work during the last few years were: (1) The study and successful fabrication of bubble domain garnet films for memory applications; (2) The growth of very thin YIG and other garnet single-crystal films for microwave-device-applications and for wide-spectra study of spontaneous and induced photomagnetic properties; (3) The discovery and employment of new garnet, single-crystal films suitable for magneto-optic display applications.

Dr. A. D'Amico of the semiconductors group told of efforts in his laboratory on LEDs and heterojunction devices, and materials and devices for infrared (ir) detection, as well as nondestructive characterization of semiconductors. His group has fabricated high-density patterns of small ir detectors with a high degree of uniformity in both the electrical and optical characteristics from element to element in the array. The approach has been rf sputter deposition on a number of substrates (e.g., Ge, SiO_2 thermally grown on Si) of both well-ordered and polycrystalline films of PbTe and Pb $Pb_xSn_{1-x}Te$. It was found that the impedances of polycrystalline-sputtered detectors could be "tailored" by changing the fractional gas composition in the sputtering atmosphere. By this technique, impedance values from a few thousand ohms up to 100 megohms could be obtained. An example of specific detectivities measured were 2×10^{10} cm $Hz^{\frac{1}{2}}/W$ (PbTe) and 8×10^{9} cm $Hz^{\frac{1}{2}}/W$ ($Pb_xSn_{1-x}Te$). The band structures of some of these films have been investigated by measurement of optical absorption coefficients and by thermoreflectance spectroscopy techniques. Some of this work, which is continuing, has been conducted in cooperation with Prof. M. Gandolfo of the Istituto Superiore di Sanitá, Rome. (Cf. G. Cappucio, C. Corsi, A. Giansantelli, M. Grandolfo, and C. Ranghiasci [*Phys. Rev.* B 15, 3986 [1977]]).

In the absence of Prof. I. Modena, the leader of the cryogenics group, there was a briefing by Dr. G. L. Romani, who stated that the activity in cryogenics includes research on devices as well as fundamental research. Romani stated that the laboratory can produce temperatures as low as 30 mK. Several aspects of cryogenic activity include superconducting magnetometry and applications, cryogenic equipment, and work related to gravitational waves, as described below.

In the work on superconducting magnetometry, the preparation and study of several kinds of devices which work on the basis of "weak superconductivity" have been of specific interest. Here, by means of standard evaporation and photolithographic techniques, special structures, consisting of constrictions on evaporated superconducting films (Al, Nb), have been fabricated. Properties of quantum interference for double bridges in a magnetic field have been observed. The interference pattern is obtained by applying an external magnetic field perpendicular to the superconducting film. The voltage modulation at the ends of the junction depends on the flux quantization in the superconducting area enclosed by the two bridges. Similar structures have been used as planar dc magnetometers.

LESS recently began studies involving rf-biased superconducting magnetometers. This type of SQUID (superconducting quantum interference device) has a periodic voltage response to an applied magnetic field. The ultrahigh magnetic flux sensitivity (10^{-20} weber), the good reliability, and the simplicity of these devices allow the utilization

of this rf SQUID in a wide range of applications. LESS has built a complete SQUID system. In one application of this system an original method was being tested to measure ultra-low ac currents (less than 10^{-14} A), and LESS was fabricating and beginning to use the apparatus to detect human heart and brain magnetic fields in a magnetically shielded room.

In progress also was the development of some cryogenic technology, with the objective of stimulating Italian industry to get into the cryogenic market. An example was the development of flow cryostats, which allow continuous temperature variations from 5 to 300 K.

The laboratory has been actively associated with a group from the University of Rome that is a participant in the collaborative effort by Italy and the US to detect gravitational radiation. A recent development of LESS is a new type of strain transducer, which makes use of a superconducting magnetometer. Some cryostats for holding "gravitational antennas" of various dimensions have also been designed and tested. With one of the smaller cryostats, magnetic levitation of an "antenna" has been performed. This technique is used to isolate the "antenna" from external noise, and functions because of the expulsion of magnetic flux by a superconductor. The static levitation inside the cryostat of a 60 kg lead bar coated with Nb-Ti foil in a magnetic field produced by superconducting coils has been accomplished. The ultimate measurement system is expected to be so sensitive that it will detect a fractional change of length of an "antenna" of the order of 10^{-18}.

Finally, according to the brief presentation by A. Tucciarone, there has been considerable effort in the laboratory on material diagnostics and characterization by using x-ray, optical, and electromagnetic techniques. One example is the measurement by x-ray diffraction of the lattice distortions caused in single-crystal thin films by film substrate lattice mismatch. Highly focusing geometries are used in this procedure that allow the utilization of large surface and full mosaic spread of the films in order to obtain diffraction spectra of high intensity without loss of resolution. Another development has been a nondestructive technique for determining the symmetry of atomic centers in crystals and thus, in particular, the crystallographic site location. The method consists of inducing anisotropy either by the linear polarization vector of an electromagnetic field or, in the case of magnetic crystals, by the magnetization vector. As the inducing vector is rotated, the angular variation of the induced anisotropy is measured. This technique, which can be more sensitive than standard techniques, has been used for determining the site preference of Fe^{2+} ions in garnets by measuring the induced linear dichroism.

In summary, this small laboratory impressed me as a very active one. LESS produces numerous publications, and there seems to be a genuine attempt to work on science that has industrial applications. Paoletti confessed that the close cooperation with industry that is sought remains elusive, but he is continuing in efforts to make it happen. (Irving Kaufman)

ENGINEERING

MICROWAVE ANTENNAS WITH POLARIZATION DIVERSITY AT EINDHOVEN UNIVERSITY

The Technical Univ. of Eindhoven, Holland, which was founded in 1956, has a large, attractive, modern campus. It accommodates a total of about 5,000 students, some 1,000 of whom are in the Electrical Engineering Department. Admission to the university is assured, by law, to all students who have graduated from the equivalent of a high school, and there are no separate entrance examinations. This results in a rather high dropout rate during the first two years, even though students have almost complete freedom in how they conduct their studies. They can choose the semester in which they want to take a particular examination and can delay this time without penalty. Further, the government is liberal in supplying grants or loans to students in need of financial aid. This lack of pressure on the students may tend to extend the total period of study. The courses are designed to give the equivalent of a master's degree in 5 years, but the average time is 6-7 years. The degree conferred is Ir., which stands for the title "engineer". A doctor's degree, which can be obtained subsequently, requires original research resulting in a thesis.

An interesting "self-marking" system is used for written examinations. The student retains a carbon copy of his examination paper and marks it after the examination by comparing

it with a supplied model answer. The marks are discussed later with the examiner, with an arbiter present in case examiner and student are unable to reach agreement.

Both educational and research activities are financed, to a large extent, by the Dutch Government, which also provides free workshops and computer facilities. The researcher is thus at least partially freed from the need of hunting for support. Nevertheless, some of the projects are funded from other sources, and R&D contracts are accepted from domestic and foreign agencies and industries.

When I visited the university recently, my hosts were Drs. M.E.J. Jeuken and Ir. V. Vokurka from the research staff of the Electric Circuit Theory and Electromagnetic Theory Group. They have developed a most interesting new microwave antenna: the corrugated elliptical horn. This device is specially suitable as a feed for reflector antennas of stationary satellite television distribution systems, in which the radiation requirements are for circularly polarized beams, with elliptical cross sections, that cover a prescribed area on the earth. Great polarization purity must be maintained so that both right- and left-hand circular polarization can be used to double the channel capacity.

The circular horn, with proper corrugation on the inside, is known to give a polarization-independent radiation pattern, but the pattern has circular symmetry. In a study supported by ESTEC (European Space Research Technology Center), Jeuken, working with J.K.H. Jansen, has been able to derive the theory of elliptical-corrugated horns and to calculate optimal dimensions of the grooves. The characteristic of such horns is that the propagation constant of even and odd modes is the same, giving radiation patterns that have an elliptical cross section and that are invariant with changes in polarization. Circular polarization can be obtained over the whole pattern. In a program supported by the antenna department of Messerschmitt-Bölkow-Blohm GmbH (MBB), Munich, FRG, two experimental elliptical horns with different ellipticities were built with carefully controlled close tolerances, for the 12 GHz band. The aperture dimensions were 4.6 $\lambda \times 2.3\ \lambda$ and $6\ \lambda \times 2\ \lambda$ respectively. The patterns were found to agree closely with those predicted and to be substantially insensitive to polarization. The cross-polarized components were smaller than -35 dB over a 10% band. The horns, which proved difficult to build, were eventually constructed through a complex electroforming technique. A thick layer of copper was first deposited onto an aluminum mandrel which was in the shape of an elliptical cone. The copper layer was then machined to the thickness required for the grooves. Next, parallel cuts were then made right through the copper to the aluminum. The resulting grooves were then filled with a conductive paste, and another layer was electroformed over the combination. The mandrel and conductive paste were then removed or dissolved, leaving the corrugated copper horn. The horn was briefly discussed in *Electronics Letters*, 27 September, 1979, and will be described in more detail at the June 1980 meeting of the IEEE Antenna and Propagation Society in Quebec, P.Q., Canada.

Both of MBB's experimental horns were tested as feeds with an offset parabolic reflector. Cross-polarized components were found to be smaller than -35 dB. The resulting beams had elliptical cross sections with a ratio of major-to-minor axes of about 1.6 or 2.3, respectively, for the two horns. Jeuken pointed out that multiple resonances giving a multiple-frequency response can be obtained by making the grooves deeper.

A different method of achieving beams with elliptical cross section has also been studied by Jeuken and his colleagues. This method involves the use of two spaced, crossed, parabolic cylinders as reflectors. Their work was based on that of C. Dragone ("An Improved Antenna for Microwave Radio Systems Consisting of Two Cylindrical Reflectors", *BSTJ* vol. 53, no. 7, Sept. 1974) who had shown that such a combination of reflectors gives an almost elliptical beam, even when it is illuminated with a feed that has a circularly symmetric radiation pattern. They expanded the theory of Dragone by including appropriate terms of the actual aperture amplitude distributions, giving a complete radiation pattern prediction including sidelobes. Using this theory, they designed and built such a reflector system with the very close tolerances that are readily obtained with cylindrical shapes. As feed, they used a circular (rather than elliptical) corrugated horn with circular polarization. The system will be tested later this year. Substantial improvements are predicted over the

WARC 77 (World Administration Radio Conference 1977) recommendations for a satellite-television-distribution system. This work was also supported by MBB.

Presently, there is much interest in testing antennas in an indoor, controlled, anechoic chamber rather than at an outdoor range. Much work has been done probing the field in front of the antenna and then calculating the pattern, making allowances for the presence of the probe. At Eindhoven, the approach has been to create a planar phase-front, with constant amplitude, in which to measure the antenna under test. The Eindhoven innovation is to create this planar field with a feed-double-reflector combination in which the double-reflector is composed of two crossed, parabolic cylinders. The experimental range, in an anechoic chamber, uses precision-parabolic cylinders about 5 ft × 5 ft in size. With this method, the useful test area is about 3 ft × 3 ft in size and has constant phase and amplitude distribution; this represents a considerable improvement in the state of the art. Antennas up to that size may be tested in that range up to frequencies of 70 GHz, although the upper frequency limit due to mechanical tolerances is believed to be about 100 GHz. The advantages claimed for this compact range are: (1) It provides a larger test zone area for the same reflector size; (2) It gives better cross-polarization performance; and (3) It has a considerably higher upper frequency limit due to the high tolerances that can be achieved with cylindrical reflectors. (T.C. Cheston)

MATERIALS SCIENCE

POLYMER PROCESSING

Turning polymer raw materials into finished plastic products is a highly specialized art. Despite sophisticated equipment for injection molding, filament winding, compression molding, and the development of new polymers and compositions, much of polymer processing is unabashed empiricism.

This situation must change. The cost of polymer raw stock is escalating; there is a growing demand, especially by the electronics and automobile industries for precision-engineered plastic components; and plastics are being called on to replace metals for structural, load-bearing purposes. An industry based on trial-and-error methods can meet these demands slowly if at all.

There are clear signs that something is being done about putting some fundamental science and sound engineering into the polymer processing industry. In an earlier article (*ESN* 33-5:189), we described the Polymer Engineering Directorate (PED), a part of the UK Science Research Council. The PED is issuing research grants to university and government laboratories to work on specific problems (identified by PED) in the polymer industry, of which one is processing. Also, the Rubber and Plastics Research Association (RAPRA, *ESN* 34-4:183), an industry/government-supported R&D organization, has a large effort in injection molding. The present article describes the three largest research groups in Europe whose only mission is R&D for all phases of polymer processing: the Institut für Kunststoffverarbeitung (IKV), at the Technical University of Aachen (Rhein-Westfalia Technike Hochschule, Aachen, FRG); the Nonmetallic Materials Department at Brunel University, Uxbridge, UK; and the Ecole d'Application des Hautes Polymères (EAHP), Strasburg, France.

IKV: The largest and most prestigious of these three groups is unquestionably the IKV. Located in the center of Aachen, IKV has a professional staff of over 70 plus a generous supply of technicians and students. It was started in 1950 by an "Association of Promoters" (Vereinigung zur Förderung des Instituts für Kunststoffverarbeitung in Industrie und Handwerk) to conduct research and provide education in all areas of plastics processing, testing, and applications. The "promoters," who today number over 200, include material suppliers, equipment manufacturers, plastics processors, and scientific institutions not only in West Germany but in the rest of Europe and in North America as well. The IKV is governed by a board of trustees, the members of which come mostly from industry. The director is Prof. Dr.-Ing. G. Menges.

The major source of income (80%) is the government: the German Research Association (Deutsche Forschungsgermeinschaft), the Association for Industrial Research (Arbeitsgemeinschaft Industrieller Forschungsvereinigungen), and the state of North-Rhine Westfalia. These funds are supplemented by contract research. Despite all this support from public funds, industry, rather than the government seems to have the biggest say in IKV's operation. Much of the research direction comes from technical committees composed of representa-

tives from industry and the IKV staff. These committees not only decide on research directions and monitor progress, but also see that R&D results are utilized by the industry.

Since IKV has its own administration and its own organizational structure, the connection between the Institute and the university is minimal; there is university membership on the board of trustees, Menges holds the Chair of Plastics Processing in the university, and many other IKV staff members hold university posts. The Mechanical Engineering Department at the university graduates about 30 students each year at the BS level with specialty in plastic processing and applications.

IKV technical activities are organized in nine Departments: Materials Technology; Injection Molding; Extrusion; Mold Construction; Joining; Reaction Foaming; Glass-Reinforced Plastics (GRP); Processing, Product and System Design; Automation and Measuring Techniques; and Education.

Dr.-Ing. J. Wortberg heads both the Injection Molding and the Extrusion Departments. As he described these departments, IKV's strong committment to computerization became very clear. They use microprocessors extensively to automate (monitor and control) molding equipment. The large computer facility at the university is used for simulations; for example, to simulate the injection molding process. By varying molding and materials parameters, they predict internal stresses, shrinkage, ejection forces, etc. They develop the analyses for simple geometries which represent components of a major part such as the fan for an automobile engine. The analyses are then combined to predict the strength and modulus of the total part. They found that their predictions were completely verified when the fan was molded and tested.

A major difficulty in the simulation work is the lack of reliable data for common molding materials, such as viscosity and thermal diffusivity as a function of temperature, pressure, and strain rate. These data, determined primarily by the Materials Technology Group, are needed for the work at IKV and by the industry itself as processing becomes more sophisticated. Wortberg expressed the optimistic belief that data manipulation can be simplified, e.g., predicting the melt-flow behavior of a filled polymer from flow data for the unfilled polymer.

Once a molding process has been simulated, the molding parameters can be optimized and the results used both in mold design and as input data for the automation of the molding operation. Wortberg pointed out that the pertinent parameters are feed temperature and pressure, and injection speed. Temperatures and pressures must be monitored along the injection nozzle and at various positions in the mold.

Wortberg described some new technologies in injection molding, the most interesting of which was powder molding. As in powder metallurgy, the heated polymer powder is injected into a mold and heat is applied to sinter the granules together. Microwave heating is the method of choice, but this technique is limited to polar polymers. Again, as in powder metallurgy, the initial molding is followed by compression molding to give the part precise dimensions. Wortberg sees this technique as applicable to crosslinking thermosets and elastomers for which, during the sintering stage and final molding, crosslinking will occur at the boundary between granules.

The activities of IKV in polymer extrusion are quite similar to their efforts in injection molding: simulation coupled with design and processing automation. Extrusion includes film formation, wire coating, and blow molding. They are experimenting with a new crosslinking polyester as a wire-coating material. The crosslinking agent is a peroxide, and heat curing is done at the nozzle by means of microwaves. Wortberg described the work on die design which, he stated, must emphasize the rheological aspects of extrusion. To illustrate his point, he noted that the rates involved are large enough that the elastic response of the polymer becomes involved. They are developing finite-element-analysis techniques for complicated nonNewtonian flow and nonisothermal conditions.

Dipl.-Ing. H. Derek described the work at IKV on GRP. Here again, computer-controlled operations dominate their activity. In the case of filament-winding complex GRP structures, the winding is first done manually, and the operator's motions are digitized and recorded on a tape. The tape may then be used repeatedly, through a microprocessor, to drive the winding automatically. They also calculate geodesic shapes for filament-wound structures; in these cases the computer generates the data for automating the winding machine. Derek also described

the group's work on computer-controlled compression molding of short-fiber sheet-molding compound (SMC). He mentioned that they find the impact strength of SMC is greatly improved by using a mixture of glass and polyester fiber.

One of the more remarkable devices I was shown at IKV was the "robot" GRP spray gun. The gun, mounted on a motorized carriage, has three degrees of motion. Needless to say, its operation can be computer controlled. The robot is used to spray short fiber GRP to form large complex shapes such as a small boat hull or a tank lining. One obvious virtue is that it can be controlled remotely and used in enclosed spaces where toxic resin fumes would prohibit manual operation.

Derek described the IKV program to develop an automobile drive shaft composed of epoxy resin reinforced by continuous graphite fiber. They are currently building a prototype using glass fiber. The plan is to use infrared heating to cure the resin and to have a feedback control to prevent heat buildup due to reaction exotherm. Curing will be done on a rotating spit.

With so much emphasis on computer control and analysis of processing, IKV has a separate group dedicated to automation: the Automation and Measuring Technique Department, headed by Dipl.-Ing. E. Bergweiler. He has a staff of 5-6 people, which is relatively small for IKV. For the most part, they are computer specialists and electronics engineers with some materials background. As such, they provide an expertise in programming, computer operation, and even some hardware design that people trained primarily in materials science usually find difficult to acquire.

The measuring-techniques aspect of Bergweiler's Department is concerned with automating test methods rather that with the actual testing. (Testing is done in the Materials Technology Department headed by Dipl.-Ing. U. Thebing.) Bergweiler is responsible for data processing and collation and for maintaining a data base of material properties and processing parameters.

Finally, it is important to mention IKV's education and training activities. Besides the engineering course in the university, IKV has 16 training centers in West Germany and one in West Berlin. These centers rely heavily on audio-visual aids, especially films for closed-circuit TV which are produced at IKV in Aachen. They also have equipment for "hands-on" training. The centers are clearly an effective means of getting R&D results into the field.

Brunel University: Prof. M. Bevis is building a polymer processing research team at Brunel University. He came to Brunel from the academic staff of the University of Liverpool in 1977 with a solid reputation in polymer science. Today Bevis heads the Nonmetallic Materials Department, which is the largest coordinated team in polymer technology in the UK, and still growing. It is a modest effort compared to the much older and better-endowed IKV, and it differs from the IKV in emphasis. Where the IKV is strong on the engineering aspects of processing, the emphasis at Brunel is more on structure/property relationships, namely the effect of processing on the microstructure of the polymer and the relationship between microstructure and mechanical properties.

About half of the department's support comes from the government, principally the Science Research Council and the Department of Industry (*ESN* 34-5:255) and the other half from contracts with private industry. All the undergraduate students are on cooperative, "sandwich," programs: for the first three years they spend 6 months at Brunel and 6 months working for private industry or for the government; the fourth year is spent entirely at Brunel. The students need not work for the same company for all three years and, in fact, after the first year the company need not be in the UK.

Dr. P.S. Allan, who came to Brunel from Liverpool with Bevis, is investigating the crystalline microstructure of injection-molded PE. In one of the projects started recently, he is studying the microstructure of thick (4 cm) section moldings and how this microstructure varies in different sections of the molded part.

Amorphous polymers such as polycarbonate, polystyrene, and polymethylmethacrylate have, of course, no crystal microstructure, but in recent years there have been claims that they have a nodular or granular structure, with granules at most a few hundred angstroms in diameter. There is much controversy about the reality of this microstructure in amorphous polymers, although the idea seems to be gaining support. However, Dr. D. Vesely is convinced that the structure that has been observed is an artifact—the result of damage by the electron beam when the polymer is examined in an electron microscope. He stated that such damage can be avoided only by using the electrons efficiently

so that observation can be completed before damage occurs. The recently developed scanning-transmission electron microscope (STEM) uses electrons more efficiently than the conventional gun microscopes, and with a STEM he is gathering evidence against a nodular microstructure in amorphous polymers.

Bevis is quite proud of his team's development of starch-filled polymers. Besides being a cheap filler, the starch renders a degree of biodegradability. These materials, especially starch-filled polyethylene, are finding wide use as packaging material. The Brunel group is trying to increase the amount of filler to lower the density, and to reduce the cost still further.

Allan, together with Bevis and Dr. W. Bonifield (Queen Mary College, Univ. of London), is trying to develop polymer composites for human bone replacement. Bonifield has made measurements of the mechanical properties of bone, especially modulus and fracture toughness, and a composite has been formulated that matches these properties. The composition of the composite is proprietary. They are presently testing the material as bone replacement in animals.

The processing of nylon filled with graphite fiber is under study by Dr. M.J. Folkes. He is concerned with the reduction of fiber length during injection molding. Rotational flow patterns cause fibers to break. Folkes uses a flow-visualization technique where a suspension of fibers in viscous silicone oil is observed as it flows through ducts constructed of glass or transparent plastic.

In another study, Folkes is investigating the morphology of styrene-butadiene-styrene (SBS) copolymers. Specifically, he wants to know how the morphology of the rigid styrene domains changes during the flow of the molten polymer. Initially, the domains are cylindrical, but during flow they are disrupted into spheres or short fibers. However, the final product is anisotropic in its mechanical properties, and this is inconsistent with spherical or short-fiber domains. Folkes thinks there may be some reformation of the cylindrical morphology by an annealing process. In future work with copolymers, he plans to study blends of homopolymers with copolymers which, he says, lead to some unusual morphologies, even three-phase systems.

Dr. K.A. Hodd is working on the ionomeric cements, made by reacting glass powders with polyacrylic acid, which look so promising as dental filling materials (*ESN* 34-2:79). Hodd noted that the very rapid cure time of the ionomers is an advantage for dental applications but a disadvantage for other purposes. He would like to find ways of slowing the cure, but the chemistry of these materials is discouragingly complex. Hodd is also investigating the use of calcium carbonate as a filler for polymers; specifically, he wants to determine how much filler can be added, without rendering the polymer unprocessable.

Under joint funding from the PED and industry, Dr. P.R. Horsby and Mr. G.R. Southern are working on twin-screw-extrusion injection molding. The advantage of the twin-screw extruder is that it reduces the shearing forces applied to the polymer mix, thus cutting down on breakup of filler, especially fibers; it also reduces shear degradation of the polymer itself. However, mixing in the twin-screw extruder is not as good as in the single-screw machines. The ultimate purpose of the work by the Brunel group is to improve British-built twin-screw machines. They hope to increase the mixing by changing the screw geometry. Their approach is largely experimental, since the theory of twin-screw extrusion is poorly developed (even the theory for single-screw is very complex). They are trying to maximize output per unit of energy input, to minimize residence time in the extruder, and, as a means of building a theory, to compare the results with various theoretical models.

EAHP: The Ecole d'Application des Hauts Polymères in Strasbourg was formed in 1963 by the Ministère de l'Education Nationale to provide engineers with a specialty for polymers to the French plastics industry, and to conduct applied and fundamental research for that industry. Initially the operations of EAHP were located at the Ecole de Chimie de Strasbourg and at nearby Mulhouse. In 1968 it was consolidated in Strasbourg and became part of the Université Louis Pasteur. The EAHP is adjacent to the Centre de Recherches sur les Macromolécules (CRM), and there is considerable interaction between the two institutions. The CRM is a government (Centre National de la Recherche Scientifique) laboratory devoted to fundamental research on polymers (*ESN* 34-2:20). Even though the work at EAHP is expressly applied, there is much communication between the EAHP and CRM, and there are even cooperative programs. The Director of EAHP is Prof. C. Wippler; my host was Dr. André Weill.

The academic program at EAHP consists of two years of course work and research. Student enrollment is limited to 16, and applicants must have a master's degree in engineering or science. Fifty percent of the course work is in polymer synthesis; the remainder is divided into structure/property relationships and the physical properties of polymers, with emphasis on commercial materials. Between the two academic years, 2 weeks are spent studying elastomers at the Ecole Supérieure des Industries du Caoutchouc (Montrouge).

The emphasis in both teaching and research at EAHP is on the engineering aspects of synthesis and of the properties of polymers pertinent to processing rather than on processing itself. Like Brunel, EAHP has a limited number of injection-molding and extrusion machines most of which are used for teaching rather than research. Unlike Brunel or IKV, EAHP has a substantial effort in polymer synthesis.

The research at EAHP is divided into short-term (one year) projects and long-term research programs. The short-term projects are generally quick-response studies to trouble-shoot industry problems. Much of this effort is in the form of on-site consulting. Long-term research is divided into polymer synthesis and the physics of molten and solid-state polymers. The synthesis work includes developing stabilizing agents for suspension polymerization and research on the fundamentals of emulsion polymerization, specifically, the transport of free radicals across the interface between the aqueous and organic phases.

J.M. Weidmaier and G.C. Meyer are synthesizing and characterizing charged-network polymers and interpenetrating-network polymers (IPN). They referred to the latter as "semi-IPN's" because they are supposedly composed of 90% polymethylmethacrylate (PMMA) and 10% polyurethane (PU). Actually, they find that 30-40% of the PU is short chain, partially reacted oligomer that can be extracted by solvent. Weidmaier remarked that they have recently been able to synthesize a true IPN, but he declined to supply details. Presumably this accomplishment came out of their current study of the kinetics of PMMA network formation in the presence of low-molecular weight PU molecules, and also the kinetics of PU network formation in the presence of acrylate monomer and linear PMMA.

Other synthesis work includes the development of specialty polymers for color photography, novel epoxies, and surface-active agents based on copolymers of styrene and quaternary vinylpyridine salts. They also have a pilot plant unit devoted to studying anionic polymerization.

Investigations on the properties of molten polymers relate directly to their behavior in processing, and much of the work at EAHP is concerned with the rheological phenomena that occur in injection and extrusion molding and in fiber formation. Weill is currently investigating flow instabilities (melt fracture) in the extrusion flow of molten, linear polyethylene. Besides the rheological work, the EAHP people are looking at additives or modifications of the chemical structure of the polymer to improve processability.

The solid-state investigations are aimed largely at the effects of processing on mechanical properties; current emphasis is on fracture resistance. Also, both mechanical and optical (birefringence) properties are measured in order to determine phase orientation and organization in copolymers such as SBS and isoprene-styrene-isoprene (ISI).

EAHP has a strong effort in polymeric adhesives. Weidmaier described his work with low-molecular-weight ISI adhesives in which he found a very strong maximum in bond strength when the copolymer had a 30 wt% isoprene content; when failure does occur, it arises from cohesive rupture of the adhesive. At this composition the two block sizes are approximately equal, the cohesive strength of the copolymer is at a maximum, and the contact between the substrate and adherend is greatest.

The research and development in plastics processing at IKV, Brunel, and EAHP is impressive, and will certainly benefit the plastics industry and technology in Europe. As a spin-off, the fundamental research on polymers, especially at Brunel and EAHP, adds appreciably to basic polymer science even though the research is labeled "applied." (Willard D. Bascom)

MEDICAL PHYSICS

OSTEOPOROSIS AND COMPTON GAMMA RAY SPECTROSCOPY: AN OLD DISEASE STUDIED BY A NEW METHOD IN JERUSALEM

The formal definition of osteoporosis in *Webster's New International Dictionary, Second Edition,* is "the absorption of bone so that the tissue becomes unusually porous and fragile, occurring especially in old age." Osteoporosis occurs with increasing incidence with age, especially in women after the menopause. The incidence in older people has been estimated at 25% or more. At this time it is not even known whether osteoporosis is a normal aging process or a specific disease entity. What occurs when the condition is present is a continuing reduction of total bone material, both as a thinning of compact cortical bone tissue and also in the number and size of cancellous trabeculae. In other words, with osteoporosis the bone mass present is insufficient and the bone density is low. The consequence is a weakening of the skeleton, and the occurrence of fractures (vertebral bodies, distal end of radius, proximal femur). A multiplicity of techniques have been proposed in recent years for skeletal mass measurement. These include measurement of cortical thickness and radiographic density, and, more recently, neutron activation for determining total body calcium content. However, none of these methods are at once sensitive enough and accurate enough to be helpful in early diagnosis. In addition, none of them measure bone density directly.

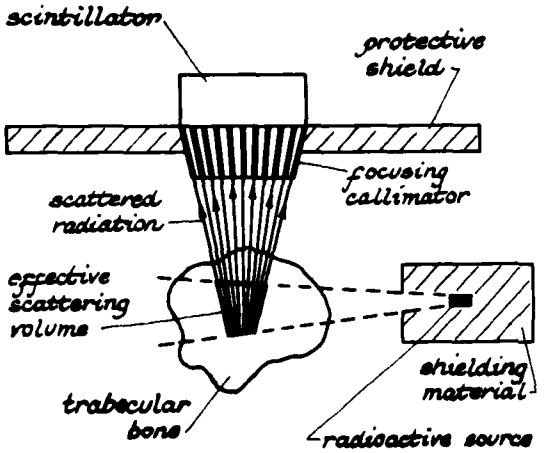
Approaches involving the direct measurement of trabecular bone density recently have been developed independently (and at about the same time) in the Univ. of Kuopio, Finland, and at Hebrew Univ. in Jerusalem. The group in Jerusalem has succeeded in developing a measurement technique to the point that it is being used currently in a clinic to examine patients. This report describes the Israeli work, a cooperative venture between the Medical Physics Group of the Racah Institute of Physics (Hebrew Univ.) headed by A. Weinreb, who is professor of physics, and the physicians (orthopedists) of the Hadassah Hospital, also an integral part of Hebrew Univ. The program is called the "Osteoporosis and Fractures Research Project." Working with Weinreb are Messrs. I. Leichter, G. Hazan, E. Loewinger, and Mrs. R. Steinberg, a biostatistician.

Weinreb's usual area of research is molecular structure. Some years ago he became interested in what could be accomplished by applying the methods and approaches of a physicist to problems in medicine, an interdisciplinary field widely known as medical physics. He quickly became interested in two specific problem areas: an early diagnostic test for osteoporosis by measuring trabecular bone density; and the detection of minute contaminant metal fragments (copper, iron) in the eye, ultimately capable of causing blindness. The investigation leading to a method of measuring bone density, which commenced in 1974, is based on an application of Compton photon scattering.

It can be shown that for elements possessing the same Z/A value (Z = atomic number, A = atomic weight), the ratio ρ/n (ρ = mass density, n = electron density) is the same. Except for hydrogen, most of the light elements present in the human body have the same Z/A value; thus n, the electron density, can be assumed to be proportional to the mass density, and not dependent on chemical composition. The intensity of a Compton-scattered beam, however, is proportional to the electron density. Thus a measurement of a Compton-scattering intensity may lead to an estimation of mass density. This is the essence of the approach adopted by the Weinreb team.

A Compton-scattering event occurs when a photon collides with an orbital electron (approximated as a "free" electron), leading to the recoil of the electron (ordinarily absorbed within the scattering material) and to the production of a scattered photon, whose energy is less than the original photon by the amount transferred to the electron. When the scattering angle is 90° (used in the Weinreb experiments), there is a simple relation between the energies of the original photons and those of the scattered photons: $(\lambda_{sc} - \lambda_{or}) = 0.024\text{Å}$ where the λs are the wavelengths of the scattered and original photons, respectively. The figure (p. 234) is a schematic representation of the arrangement of radioactive source, the scatterer [sample or forearm of patient] and the detector (shown with a focusing collimator). The source used is 0.5 Curies (Ci) ^{137}Cs (half-life $\sim$ 30 years), with approximately monochromatic radiation of 662 keV. The energy of the Compton-scattered photons at 90° is 288 keV. The relatively high energy source was chosen to minimize problems of absorption

and dose for the soft tissues overlying the bone tissue, and for the convenience of the relatively long half-life. At the same time, the high energy poses a problem for shielding the detecting crystal against direct radiation from the source. To ensure that the incident beam lies well within the bone-scattering volume, the radiation source is collimated, as indicated in the sketch.



The focusing collimator "sees" a circle with a diameter of 2 cm, and tends to minimize the detection of multiply-scattered photons. Actually, the choice of a lower energy source would lessen many of the measurement problems, but it also would require attention to the greater absorption of the overlying tissue and the thin layer of cortical bone. The scattered radiation is detected by a NaI(Tl) crystal, a photomultiplier, and a single channel analyzer. For the patient, the procedure calls for a series of ten measurements, each lasting 1/2 minute. The overall absorbed radiation dose is about 2 rad in a relatively small tissue volume of 2.5 cm^3. This absorbed dose is comparable to that resulting from a conventional radiographic study of the abdomen or spine.

The accuracy of the method was determined through a series of measurements on 14 liquids of known densities. A graph of the Compto' scatter counts vs the known densities was well represented by a straight line fitted by least squares to the data points. The average vertical deviation of the points from the straight line was 1.3% of the average density. Some *in vitro* experiments with a chicken bone placed in a prism of wood to simulate soft tissue demonstrated the ability of the Compton-scattering technique to differentiate between bone and soft tissue. The system was calibrated by using materials of known density, and by measuring the scattering effects of soft tissue (represented by water). The reproducibility of the *in vivo* measurements was checked by repeated examinations on a number of subjects at 1-month intervals. When the positioning of the patient's forearm is properly controlled (position of maximum scattering intensity), an average precision of approximately 2% is achieved.

The diagnosis of osteoporosis requires an accurate and sensitive method of measuring the physical characteristics of bone. No existing method is totally acceptable. Thus, in the absence of a good standard of comparison, the Weinreb team compared the results of their method with the clinical diagnosis based on a radiographic assessment of the spine. Each radiograph was examined by a team of physicians who used a predetermined basis to grade their diagnosis of osteoporosis on a scale of 0 (normal) and 1-4, corresponding to a rate of progression from questionable to severe. The comparisons were made for an initial group of 50 subjects whose spine radiographs and Compton-scattering measurements had been taken.

The subjects were divided into 3 groups in accordance with bone density values obtained from the Compton-scattering measurement: (1) 1.0-1.24 g/cm^3; (2) 1.25-1.29 g/cm^3; (3) 1.3 and over g/cm^3.

The spinal radiographs of the majority of subjects with radial bone density equal to or greater than 1.3 g/cm^3 showed no signs of osteoporosis. For the group with lowest densities (less than 1.25 g/cm^3), the spinal radiographs of all but two subjects showed definite signs of osteoporosis. Even with the two exceptions, radiographs of the hand showed that one had definite signs, and the other, suspected signs, of osteoporosis. (In some individuals signs of osteoporosis will appear earlier in the hands.) For most subjects with densities less than 1.20 g/cm^3, the spinal radiographs showed advanced degrees of osteoporosis (grade 2 or more). In the intermediate range of densities (1.25-1.29 g/cm^3), the results for the spinal radiographs were mixed, with four cases showing signs of osteoporosis and three whose spinal radiographs were judged as normal.

Thus it appears that the measurement of bone density by Compton scattering provides a useful tool in the diagnosis of osteoporosis. In the case of severe disease, the condition can, of course, be determined radiographically However, when the diagnosis based on radiography (grade 1) is questionable, the scattering measurement may provide more information in terms of the value of the bone density. At this stage, the method warrants further study and should be considered as a valuable *in vivo*, noninvasive technique for assessing osteoporosis.

Currently, the measurement of bone density is being used in Israel in a group of subjects involved in an ongoing epidemiological study of osteoporosis. The addition of a new capability for assessing the subject via measurement of bone density provided another quantitative tool for the survey. As long ago as 1967 it had been decided to determine the incidence of osteoporosis in Israel for persons over 45 years of age (to 84 as a practical cut off). Citizens on the electoral rolls were invited to become subjects in the survey. The benefits to them would be health-related knowledge about the condition of their bones, whether or not there were indications of osteoporosis. At this time the group under study includes 500 individuals who were identified as osteoporotics, plus a control group. The subjects are given an extensive examination including a medical-history write-up, blood and urine tests, lumbar-spine radiographs and, of course, the Compton-scatter measurement to determine the trabecular bone density in the radius. It is expected that the study will be concluded by 1982. (Moses A. Greenfield)

OCEANOGRAPHY

COASTAL AND MARINE APPLICATIONS OF REMOTE SENSING

The Sixth Annual Conference of the United Kingdom Remote Sensing Society was held at the University of Dundee, Scotland, on 18 and 19 December 1979. Over 100 delegates representing nine countries attended, and 31 papers were presented. The meeting was well conducted; Dr. Peter Baylis, who had convened the gathering, allowed sufficient time for most of the speakers to respond to questions and comments from the audience after completing their presentations. Baylis and his colleague, Mr. R.V.H. Brush, are from the Department of Electric and Electronic Engineering of the University of Dundee. They are well known in European remote-sensing-circles for the high-quality satellite cloud photographs which they produce and distribute from their own homemade receiving station.

Only a few of the papers are reviewed here. Others will be covered in later *ESN* editions when individual articles are written about various UK laboratories.

Mr. B. Wannamaker from the Supreme Allied Commander Atlantic Antisubmarine Warfare Research Center (SACLANTCEN) in La Spezia, Italy, spoke on the use of digitalized TIROS-N (Television Infrared Observation Satellite—a polar-orbiting environmental satellite launched on 13 October 1978) Automated Picture Transmission (APT) data in oceanographic research in the Mediterranean Sea and the Eastern Atlantic Ocean. To minimize signal degradation and remove local noise, a computer-controlled steerable antenna receiving station is being constructed. The TIROS-N can cover the whole Mediterranean in two passes, and in combination with the NOAA (National Oceanographic & Atmospheric Administration) 6 satellites will be able to obtain four complete coverages daily. In clear areas TIRUS-N APT will give near-surface water temperature with a horizontal resolution of 4 km. These data will be better for air-sea interaction studies than those derived from XBTs (expendable bathythermographs), because the latter do not start to record correct temperatures until they have reached a depth of approximately 4 m. For more detailed work, the APT data will be supplemented by Advanced Very High Resolution Radiometer (AVHRR) data received on magnetic tape from an external source, which will increase resolution output to 1.1 km.

The satellite output quantities will be combined with information from research vessels at sea and historical data banks to study the dynamics of fronts and eddies in the surface waters of the Mediterranean and Eastern Atlantic areas. TIROS-N data will also be received in real time aboard ship by a fixed omni-directional antenna which will be used to direct the vessel to areas of scientific interest shown on the APT imagery.

One of the most interesting papers was given by Dr. T.D. Allan (UK Institute of Oceanographic Sciences [IOS],

Wormley, Godalming). He spoke on the preliminary analysis of SEASAT's (Sea Satellite) Synthetic Aperture Radar (SAR) imagery of the ocean and seas around Europe. The system swept a 100-km swath as it made 53 passes (272 minutes of data) over Europe between 1 August and 10 October 1978. Fortunately these included 20 passes over the Joint Air Sea Interaction (JASIN) experiment area northwest of Scotland where twelve research ships were carrying out the largest operation of this kind ever attempted. JASIN scientists were able to obtain a large quantity of high-quality ground truth data for calibration of SEASAT's sensors. Comparative analyses between SAR imagery and JASIN ground truth measurements are still underway at this time.

SAR sea-surface imagery has a tremendous advantage over visual and infrared optical reproductions because it operates day and night independently of prevailing meteorological conditions. The imagery that has been processed to date shows remarkably detailed pictures of internal wave fields, surface-swell direction and wave length, natural and man-made slicks, and detailed topographical features of the near-coastal seafloor. Scientists have been astonished at the clarity of SAR pictures of sand banks and internal waves in the English Channel, and extensive surface slicks in the Mediterranean. Deep water internal waves were seen in the Bay of Biscay, with different wave trains moving in several directions. While SAR gave a good picture of surface wave direction and period, SEASAT's radar altimeter was able to measure the surface wave height spectrum.

Mr. G. Paci of the European Space Agency (ESA), headquartered in Paris, France, discussed the status of ongoing planning for the Coastal Ocean Monitoring System (COMS). A feasibility study of the COMS program was carried out by the British Aerospace Dynamics Group and the first launching from a European consortium launch vehicle, *ARIANE*, is scheduled for 1985. Tentative selection of sensors has been made by an ESA users' group, which includes a ten-channel radiometer scanning the frequency spectrum from 0.415 to 11.5 mm. The individual channels would be allocated as follows: (1) Dissolved yellow substance, (2) Phytoplankton, (3) Phytoplankton and turbidity, (4)-(6) Turbidity, (7), (8), and (10) Atmospheric corrections for water vapor, and (9) Sea surface temperature. The only other sensor mentioned was SAR, which if included should gladden the hearts of many researchers in the field who have till now been able to study only SEASAT SAR imagery. In addition, precision sea level measurements and monitoring of certain ocean pollutants can be carried out. In consonance with the satellite hardware, ESA is planning to develop an affordable down-station terminal which the Agency hopes to distribute on a global basis, enabling worldwide data dissemination in near real time.

Dr. Claudine Valerio (Centre d' d'Etudes Techniques de l'Equipment, Aix en Province, France), described a multispectral digital teledetection system for aircraft photography consisting of a digital sensor, which permits automatic analysis. She has been working with this equipment for the past five years.

From a commercial standpoint, France, with many holiday beaches, is obviously eager to keep her coasts sewage-free. It has been found that the pattern of pollutants from coastal outfalls changes rapidly with wind and tide conditions. A synoptic picture from samples taken by boat must, by nature, be an incomplete average of what really happens to materials emanating from outfalls.

Valerio's system has been used to study the dispersion of sewage plumes in the sea, either from their color (spectral radiance) or by simulation with a fluorescent tracer. Rhodamine-B dye is used because it is the least expensive and an airborne system can detect it quantitatively in very low concentrations, (i.e., 10^{-11} g/cm^2 in a water column). In one study off the coast of Corsica where the water is extremely clear, the column over which the dye was integrated extended to a depth of 7 m. The system's digital output is presented as a smooth color picture with no detectable background noise or artifacts.

The uniqueness of the method lies in the spatial quantification of pollutants or dye found in the water on a vertical path downwards from the surface. For this, highly refined photometric techniques are used. The actual analysis is now done by the Laboratoire d'Astronomie Spatiale in Marseille. The cost for a study, including aircraft (8 hours of flight time), dye, and analysis, averages about $18,000.

The quality and quantity of the information presented in Valerio's slides were very impressive, and the fact that color pictures of such high

quality can be made digitally is indeed an advancement in the state of the art.

Prof. A.P. Cracknell is the head of a group of research workers from the Departments of Physics and Geology at the University of Dundee. They have been using Landsat-2 multi-spectral scanner data to study the distribution of marine pollutants and sediments, and to map the location of sandbanks in and at the mouth of the Tay estuary. Cracknell showed that sandbanks can be clearly delineated, even at high tide, by comparing *in situ* water depth surveys with satellite imagery. This is a quick, inexpensive and accurate method of checking the location of sandbanks on Admiralty charts to detect changes in shallow water depth contours that have occurred between the time of the original chart surveys and more recent satellite data. In the example he gave, there were major differences between the location of sandbanks on the charts for the approaches to the Tay estuary and their location derived from satellite imagery.

At the present time, Cracknell's group is mapping the sediment distribution within the estuary for ground truth to compare with color scanning data from aircraft and multi-spectral satellite scanner data.

Mr. A. Citeau (Office de la Recherche Scientifique et d'Outre-Mar, Bondy, France), spoke on the use of Meteorological Satellite (METEOSAT) products in fishing and fisheries research. His work has been done in South American, Asian, and West African waters. Using West African equatorial waters as an example, he related that migrations of some fish-species (i.e., sardines) were controlled by changes in water temperature.

In another study of horizontal thermal discontinuities in the above area (see ONRL R-1-79) Citeau found that Rhodamine-B dye spread out along the frontal walls without mixing across the discontinuity. There was a sharp delineation in the dye concentration at each front as the dye moved down the edge of the wall with some downstream surface diffusion.

Dr. T. Phulpin (Centre de Meteorologie Spatiale, Lannion, France) discussed atmospheric effects upon the radiometric determination at three infrared atmospheric windows. He stated that with data from three windows, sea surface temperature could be inferred to an accuracy of better than ±0.3K and that an estimate of total atmospheric water vapor content could be derived from the above determination to an accuracy of better than ±0.3%. His statements evoked extensive discussion from the audience but the consensus was that ground truth could not be obtained with sufficient precision to prove or disprove Phulpin's premise (e.g., atmospheric water vapor content varies too greatly in both the time and space dimensions).

The widespread interest in remote sensing in almost all European countries was illustrated by the variegated backgrounds of the attending delegates. It was one of the most heterogeneous groups of scientists and engineers ever assembled at one time, ranging from geographers to space physicists. (Wayne V. Burt & Clayton Spikes)

THE PHYSICAL OCEANOGRAPHY DEPARTMENT OF THE UNIVERSITY COLLEGE OF NORTH WALES

The Marine Science laboratories of the University College of North Wales are located in the resort town of Menai Bridge on the island of Anglesey. The rest of the university is located across the Menai strait on the mainland at Bangor. With a staff of about 100 and a like number of graduate students, the laboratories comprise the largest university marine science complex in western Europe. They are occupied by the Department of Physical Oceanography, the Department of Marine Biology (*ESN* 26-6:161), and the Unit of Marine Invertebrate Biology, a component of the UK Natural Environment Research Council (a government body). The complex is growing, with funding available for the construction of a new auditorium, a library, and a new building for physical oceanography. It operates its own specially designed, 26.8 m stern-trawler research vessel, *Prince Madog*, named after a legendary Welsh prince who is credited with discovering North America in the 12th century. The vessel is perhaps unique among university research vessels in that its operating costs are paid out of the university's funds for operating buildings and grounds.

This article is concerned with activities in the Department of Physical Oceanography, which conducts research and instructional programs in marine chemistry, marine geology, marine geophysics, and marine geotechnics.

Prof. John Darbyshire is chairman of the department. As a World-War-II armed-forces meteorologist he was taught sea and swell forecasting, and he has been doing research on waves since that

time. At present, he is studying wave-related beach processes (rip currents, cusps, and erosion) in Hell's Mouth Bay. The bay, on the south coast of Lleyn Penninsula in Wales, is exposed to the full fury of stormy seas and swells from the Atlantic Ocean. During storms, the energy in the surf is so great that sand covers Darbyshire's wave-pressure sensors. For this reason he is developing a seismic wave sensor for use in Hell's Mouth Bay (The sensor is similar to the system used by Oregon State Univ.) A sensitive seimsograph is placed on the beach; when waves break on the beach the earth is jarred enough for the seismograph to record the timing and intensity of each of the jars. The seismograph record is calibrated with actual wave measurements.) Darbyshire is also working on a numerical model of wave refraction and diffraction, based on Berkoff's wave-equation and finite-difference techniques, that will be applicable to water of any depth.

Dr. J. Simpson, a physical oceanographer, directs a research team of a dozen persons, including 6 students working on their PhD theses. He also directs a 12-month course leading to the MS degree. Students take a common set of core courses concerned with the structure and dynamics of the ocean and also courses covering diverse but related aspects of oceanography. These courses are followed by a term of optional advanced courses in either dynamic oceanography or geophysics. The last two terms of the course are spent on individual research projects. Almost half the students in the MS program are foreigners.

Simpson's main interests are in the structure and dynamics of shelf seas and frontal structures in shelf seas and estuaries. His senior assistant, J. Hunter, is supported by contracts with oil companies. Hunter's main interest is in modeling tidal streams around the United Kingdom which must be known with more precision than in the past in order to predict the movements of oil spills.

Simpson and a student, D. Bowers, have used NOAA 5 infrared imagery to study the location and movement of sea fronts in the Irish Sea and adjacent seas. After tidal advection is subtracted, the fronts, which occur in summer, show remarkable consistency in their position. They are found within 10 to 15 km (plus or minus) of their mean positions. Strangely, they do not adjust to the very strong semi-monthly variations in tidal stirring. Simpson attributes this lack of adjustment to feedback processes in vertical mixing.

The fronts line up along contours of a mixing coefficient h/v^2, where h is the depth of the water and v is the mean velocity of spring tides. Cold, well-mixed water lies on one side of each front and stratified water on the other. The stratified water is warm at the surface and cold at the bottom. The fronts act as barriers to horizontal cross-frontal mixing, with the result that distinctly different water masses are found on each side of a front. Regular fronts are found running northward from the northern tip of Ireland; between the Isle of Man and Dublin, Ireland; running north and south, halfway between the Isle of Man and England; in Cardigan Bay; and running across St. George's Channel between Wales and southern Ireland.

Simpson and another of his students, R. Mines, have studied a sharp tidal intrusion front in the Seiont Estuary on the Welsh coast. Salinity at the front may vary by as much as 30 o/oo (parts per thousand) in distances and depths of the order of one meter. The front, which can be seen clearly, is delineated by two boundaries which point up the estuary and converge near the estuarine center. One of the most difficult tasks that Simpson and his group work on is trying to determine residual currents in the Irish Sea, where tidal and wind-driven currents may be up to 100 times greater than residual currents. Radio-tracked drogues and neutral-density floats seem to have the most promise for this effort.

S. Buchan works on applied submarine sediment mechanics, usually under contract to various industries including Amoco, Texaco, and British Petroleum. Buchan is doing a systematic coring survey of the Irish and Celtic Seas. He uses a small gravity corer to recover cores from 1 to 3 ft. in length. He also is mapping sand and gravel beds for possible commercial exploitation, is determining anchor-holding properties for supertankers and the rate of settlement of bottom sediments under load, and is endeavoring to relate acoustic properties and the presence or absence of sand and gravel.

The marine geologist in the department, Dr. D.C. Jago, is a newcomer to the staff. He carried out a study of the sediments in the small Taf estuary on the south coast of Wales. The Taf is interesting and peculiar because it is filling rapidly with sediments from the continental shelf, outside the mouth of the estuary.

Periodic surveys of the estuary show that sand of remarkably uniform structure is accumulating at a mean vertical rate of up to 0.23 m per year. This is about two orders of magnitude greater than the mean rate of accumulation in estuaries since the Pleistocene Age. The Taf was a port in historic times, but now most of it is dry for about half the tidal cycle, and only small boats can use it during high tide.

The inward movement of sediments in the Taf estuary is attributed to storm waves and tidal asymmetry. The storm waves stir up the sediment on the shelf and keep the sediment in suspension. The duration of the flood tide is only about one fourth as long as the duration of the ebb tide; consequently, peak tidal currents are much higher on the flood than on the ebb. The asymmetry is partly attributed to the effects of the shallow water on the shelf, but the primary reason is the fact that the tide must rise about two meters at the mouth of the estuary before it enters the estuary in force when it already has built up speed and momentum. There is a strong linear relationship between the rate of accretion of sand between surveys and the percentage of time with strong westerly winds equal to or greater than 20 knots. The wind waves stir up the sediment, and strong flood-tidal currents carry it into the estuary where it is deposited when the currents die down at the end of the flood.

Dr. P. Foster directs the marine chemistry program for the department. His interests include the uptake of trace metals by marine organisms, the chemistry of Liverpool Bay, the leaching of mine wastes, and chemical-base-line studies in marine areas subjected to industrial pollution.

For 2 years, Foster grew barnacles (Balanus Balanoides) below a raft in the Menai Strait. He determined the seasonal cycle of zinc in the animal's body, other soft tissue, and shell, and related the concentrations to physiological conditions. He also determined the rate of uptake of copper, manganese, calcium, and iron.

Foster regularly carries out very complete chemical studies of the waters of Liverpool Bay. He employs a continuous, online system to determine the concentrations of most of the chemicals in the surface layer (2 m depth). Samples are also taken at depth on a 10-mile grid of 34 stations. His broad objective is to explain the month-to-month macro-micro variations in the chemistry of Liverpool Bay.

There is an old copper mine near the laboratories, and an acid stream flows from the mine area into the Irish Sea. The stream is heavily loaded with copper, zinc, iron, and manganese that have leached out of the mine tailings. For two or three hours at high tide, there is a mixture of sea water and the acid mine waste in the mouth of the stream. The iron precipitates first, leaving an active surface for the adsorption of other metals. Foster has done a great deal of laboratory work to simulate and study the processes involved in precipitation and adsorption.

D. Taylor Smith and his colleague, Dr. A. Davis, are marine geotechnologists. Smith currently is the editor of *Marine Geotechnology*, the international journal of sea-floor science and engineering. He and Davis offer a year-long MS course in marine geotechnics to an average of 6 students and have three students working on PhD theses in the subject. The course is a combination of geology, geophysics, oceanography, and civil engineering. Many of their graduates are employed in the offshore oil industry.

Their main research thrust is the study of load bearing properties of marine sediments. All the geophysical properties of sediments are related to the soil-mechanics properties. Thus, geophysical techniques can be used to define *in situ* dynamic and elastic properties of soils and rocks. Smith and Davis have developed a technique to measure seismic-compressional and sheer-wave velocities and sediment densities, from which they can compute the bulk modulus (or compressibility) and the shear modulus (or rigidity). Tides and waves act on gravity platforms which are placed on the bottom with cyclic loading being transmitted to the sediments. If the pore pressure in the sediment cannot dissipate, it will continue to build up and may cause the bottom material to fail. Under certain conditions, both sand and clay will liquify and flow. This problem is being attacked in a study of shear waves.

I was surprised at the sheer volume of research under way in comparison with the size of the senior staff at the Department of Oceanography. The staff and students radiate an infectious enthusiasm. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH AT ISRAELI UNIVERSITIES

There are just seven institutions of higher education in the State of Israel. The three oldest, all formed (in some cases under different names) before the State existed, are the most prestigious in technical subjects: The Weizmann Institute of Science, in Rehovot, a southern suburb of Tel Aviv, especially in the natural sciences; the Hebrew University, in Jerusalem, especially in mathematics; and the Technion, or Israel Institute of Technology, in Haifa, especially in engineering. Tel Aviv University (TAU) was founded shortly after the formation of the State, and is now the largest, with 20,000 students. The other three are all comparatively new: Haifa University, distinguished by its 30-story Eshkol Tower built on the top of Mt. Carmel, the most visible feature in Haifa; Bar-Ilan University in Tel Aviv; and Ben Gurion University of the Negev (BGU) in Beersheeva. Operations research (OR) is taught only at three of these, the Technion, TAU, and BGU, although there are mathematics courses related to OR at some of the other schools.

TECHNION

OR in Israel started at the Technion in the 1950s under Pinhas Naor (who was killed in a tragic airplane accident in 1969), and many of the top OR people in Israel are alumni of the Technion. Most Israeli OR professors have a graduate degree of some sort from the US or have spent sabbaticals as visiting professors at American universities, or both.

The Technion has about 9,000 students, of whom about 3,000 are graduate students, and 1,000 faculty. The university is divided into about 15 "Faculties", some of which are large (like "Schools" in the US), while others are smaller (like "Departments"). The Faculty of Industrial Engineering and Management (formerly Industrial and Management Engineering—the Hebrew is ambiguous), or IEM, is divided into six areas: Industrial Engineering, Operations Research, Economics, Statistics, Industrial Management, and Behavioral Science; the last-named has as subareas labor relations and manpower, organizational behavior, and industrial psychology. The Industrial Engineering area has just started a new program in human engineering; and IEM has a joint program in Management Information Systems with Computer Science. Thus, there are a wide variety of programs available to their 600 undergraduate students and 350 graduate students. The undergraduate programs generally take four years, like the US, although many Israeli programs, like those in the UK, take only three.

The dean of this faculty is Mordecai Avriel, who took his PhD at Stanford under D. Wilde, well known in nonlinear programming. The degree was nominally in chemical engineering, but Avriel's heart was never really in that area, and he shifted over to the IEM faculty several years ago. He has spent many years in the US since his doctorate, working for Mobil Oil Co., for the University of California at Berkeley, and most recently (1975-76) at Stanford. While there he worked with G. Danzig on modeling energy policy. Now he has a substantial long-term contract from the Israel Ministry of Energy to do similar work. At the present time he is working on the first phase of this contract with a visiting professor, William Marcuse, determining the types of research that should be done. Marcuse, Head of the Economic Analysis Division at Brookhaven National Laboratory (NY) has built a tree of energy-related objectives. Starting with the overall Israeli objective "establish a homeland for the Jewish people—to enjoy the highest possible level of economic, social, and cultural well being and to live in peace"—he goes through various goals and subgoals. Thus, one of the goals is to increase the supply of energy; and under this, one subgoal is development of solar energy for low-temperature applications. Under the goal of decreasing demand for energy, one subgoal is retrofitting existing buildings (for example, with insulation) to increase efficiency. He ends up with some 80 energy subgoals. For each of these he does a rough calculation as to the amount of energy improvement (say between .1 - 1%, or .01 - .1%, or .001 - .01% of Israel's total energy use); the extent to which the proposed method is competitive in cost with the existing method (twice as expensive, five times as expensive, etc.); and the risk (the probability that the proposal would be successful). These

are combined to put each subgoal into high, medium, or low priority. Finally he examines whether the government is working on each of these. If the government is working on a "low", or not working on a "high", then it becomes appropriate to do the calculation over more carefully to find out whether the initial calculation was wrong or whether the government is wrong.

Perhaps the best-known member of the faculty is Benjamin Avi-Itzhak, who took his doctorate there 20 years ago under Naor. He was the first Dean in 1969 when IEM became a faculty, and he has been visiting professor for a year or more at Stanford, Cornell, Case, and CUNY in the US, but he always returns to the Technion. He also is working on energy models, specifically reworking and reprogramming a Stanford model to make it more realistic. It is a large staircase-structure LP model (see *ESN* 33-11:479); Avi-Itzhak's modifications have, among other things, made the model respond to scarcity and to changes in price. Avriel's model is national—the total economy of the State with emphasis on energy; Avi-Itzhak's goes to the micro-level, with emphasis on energy in marine transport (he has published extensively on such transport under energy constraints).

Moshe Pollatschek is Hungarian; he believes that he is distantly related to the famous OR mathematician Pollacek (who spells his name the Czech way). He did his doctoral work at the Technion under Avi-Itzhak and had a post-doctoral year at Stanford. He is now interested in the management/computer interface, and in hierarchical structures and models thereof; this leads to specific questions such as "how many subordinates should one have?", or "what is the limit on shortening reports for superiors to read?" He believes that objective, quantitative answers to such questions can be obtained from appropriate analysis and has obtained some seed money with hopes of a larger contract.

Like most Technion professors, Pollatschek consults to supplement his meager university income. He told me about some successful simulations he had introduced into industry, and also some inventory-control systems. In particular, he has implemented an economic order quantity (EOQ) under conditions of inflation (Israel now has approximately 100% per annum inflation, which renders most EOQ formulas worthless.) Basically he ignores reorder costs, and uses instead a limitation, F, representing the capacity to purchase; the implication is that the reorder cost is actually the cost of increasing this capacity. Then if one orders a quantity Q_i of item i at a nominal price c_i per unit, there is an average of $Q_i/2$ on hand, and the total cost is $\Sigma\, c_iQ_i/2$ and this term is to be minimized, subject to the constraint $\Sigma\, N_i/Q_i \leq F$ where N_i is the annual demand. As in the classical case, the EOQ, the optimal value of Q_i, is proportional to $\sqrt{N_i/c_i}$. In the actual implementation (at a large chemical and fertilizer company), there were two constraints, one each for the capacity to order local and foreign purchases. Picture graphs were prepared so that the policy could be implemented by uneducated operators. The system appears to have worked successfully.

Yuri Passy (most Israelis with this common first name choose to transliterate it into English as Uri—Yuri is the usual transliteration of a common Russian name) also took his doctorate under Wilde, and has been in IEM at the Technion for a dozen years. His research has been on duality in nonconvex programming, on geometric programming, and on multi-objective optimization. In connection with the last-named, he has been working with the Tel Aviv police to determine their manpower allocations. What are the utility functions? Would you prefer to solve 80% of the homicides and 50% of the burglaries or 90% of the homicides and 20% of the burglaries? And whose functions should one use? It may be that the public is very sensitive to rape while the police feel that commercial burglary is more important.

Eli Schleifer took his PhD under J.D.C. Little at MIT. After spending many years in the US, he came to the Technion in 1971. He is interested in trying to formalize certain things which "everybody knows". For example, in any large logistic system, it is possible to forecast "top-down" (what are the total sales going to be, and what fraction of that total comes from each item?) or "bottom-up" (what is the best estimate for each item, and then what is the total?). Everyone knows that for the short term, bottom-up is better; Schleifer wants to formalize this. Similarly, the inherently large variance of low-demand items tends to degrade every forecasting system, leading to people doing their

own back-of-the envelope forecasts; Schleifer hopes to get a better operational understanding of this phenomenon. Again, a measure of effectiveness for certain inventory systems is the fraction of demands which could be filled; but if a job requires 100 items, and 99 of them can be filled, it may be that the job cannot be completed and real effectiveness has been zero even though the "% fill" is 99. Finally, Schleifer is interested in the effectiveness of marketing efforts which are either concentrated or spread; the literature is mixed, but mostly recommends concentration, and this is in fact correct, although most people's intuition tells them to spread the effort. Schleifer believes he has models which explain this phenomenon better than has been done in the past. These kinds of research efforts strike me as being very exciting.

TEL AVIV UNIVERSITY

One of the most famous Israeli OR people is Adi Ben-Israel, who also was a graduate student at the Technion in the 1950s, although he got his doctorate under A. Charnes at Northwestern. He was a professor at Northwestern, and now holds a chair at Delaware, but he seems always to manage to spend a lot of time in Israel—usually at the Technion, but this year he was visiting professor at TAU when I visited. He is continuing his work in generalized matrices, and is also doing OR applications, one of which is described in (*ESN* 34-4:193).

The Business School is one of the largest Faculties at TAU, with 60 full-time and many part-time faculty members. They graduate 200 undergraduates per year in accounting, and are just starting a four-year undergraduate program in management and economics which is expected to become equally large. They now have 1100 MBA students and another 250 MSc candidates studying OR, management information systems, or organizational behavior. Most of these students are part timers, working during the day and going to school at night.

Avram Beja took his doctorate at Stanford under the famous economist K. Arrow (but in the Engineering School, not in the Economics Department). He is interested in the applications of optimal control theory to the control of stochastic systems; and is applying this tool to the construction of mathematical models which describe market systems as stochastic systems. In particular, he has had some success with the description of capital markets—for example, of the instabilities that may result when some participants speculate on their perceived trends. Beja's work appears to be well respected internationally, and he may be the most distinguished permanent member of this faculty. He is currently president of the Operations Research Society of Israel.

Israel Zang took a DSc. in mathematical programming under Avriel, nominally in chemical engineering, but as noted above, really in nonlinear programming. He works in generalized convexity and unconstrained optimization, most recently in application to difficult problems in nonlinear regression analysis, such as those appearing in econometrics. He uses a smoothing approach to nondifferentiable functions, and minimizes, for example, piecewise quadratic approximations. He has also applied these concepts to minimax optimization, including Tchebycheff regression (i.e., minimizing the sum of absolute deviations instead of the more usual least-squares approach). If the regression is linear this leads to a linear programming problem, but Zang has been interested in nonlinear models. Finally, he has been interested in pricing resources which have been allocated by mathematic programming—a problem recently discussed in these pages (*ESN* 33-11:479).

Miron Gross took a PhD in solid state physics as well as an MSc in OR, and is now working on a PhD in OR, all at TAU. His research topic is optimal control of the urban developer's decisions, using calculus of variations and the Pontryagin maximum principle. The canonical problem is to determine when to develop a piece of urban land; or more specifically to determine the continuous variable u, the rate of development, as a function of time, t. If the rate of development is the same as the rate of sales, the optimal policy is given by Fig. 1; (p. 243) but if the demand depends only on cumulative sales $y = \int^t u\,dt$, then the optimal policy is given by Fig. 2, which may define a business cycle, and in any case leads to a cumulative curve like Fig. 3. Town planners are familiar with the curve of Fig. 3, but do not understand why it arises.

Gross has some fascinating and perhaps nonintuitive conclusions from his analysis, such as insight into the relative social value of monopolistic and competitive development in such situations. Using the classical

criterion function of the sum of producers' surplus and consumers' surplus, he finds that competition is socially better if demand is a function of the rate of development (u), but that monopoly is better if demand is a function of cumulative development (y).

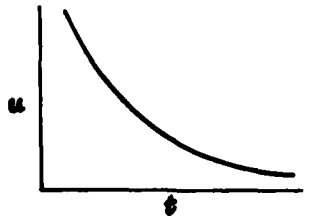


Fig. 1.

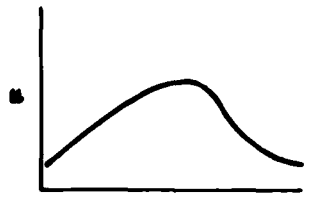


Fig. 2

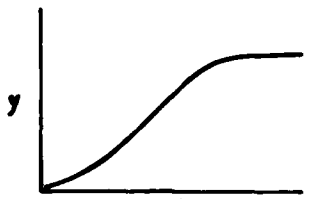


Fig. 3

Jacob Zehavi took his doctorate at the University of Pennsylvania in systems engineering, then spent a year at UCLA and one at Cornell before returning to TAU in 1976. He is working on energy models quite different from those of Avriel although both are funded by the Ministry of Energy. Zehavi is interested in investment—specifically, how the government should invest its money in the coming years and what prices should be. While a number of other people are involved in the project, Zehavi is primarily interested in the supply side of the equation: given the demand, what is the optimal means of energy generation to meet it? what are the elasticities? what is the equilibrium situation? how do uncertainties and risks affect investment decisions? (he pointed out that Israel will have nuclear energy if and only if the American President approves it.)

Zehavi is also working on a model for the cost of electricity as a function of time of day and day of the year. They have an algorithm and a computer package for determining this at any point over the planning horizon. They are collaborating with Nathan Arad (*ESN* 34-4:173) on peak-load pricing, and are trying to determine the elasticities over time (AM vs PM for example) which is needed to determine the benefits of peak-load pricing.

BEN GURION UNIVERSITY OF THE NEGEV

At BGU, OR is taught in the Department of Industrial Engineering and Management (IEM) in the Faculty of Engineering Sciences. The first name of Dean Wisniak, who heads this faculty, sounds like "Hymie", which is a nickname for the common Israeli first name of Haym. In fact, however, Wisniak is a Chilean whose first name is Jaime. He speaks fluent English with a barely detectable accent, in spite of the fact that his principal languages are Spanish and Hebrew, and that he feels more comfortable in several other languages than English! This is typical of Israel. So is the barbed wire I saw around the campus of this university.

The headship of the IEM Department rotates. At the moment it is held by Nachum Finger, an Israeli who was born in Russia and who took his PhD at Columbia under Seymour Melman. His research interests are in productivity, and the impact of subsidies on industrial management.

Helman Stern took his doctorate at the University of California (Berkeley) and was a professor at Rensselaer before coming to BGU. He is interested in problems of routing and scheduling as applied to fleets of ships or automotive vehicles. Given a set of trips—their origins and destinations and the starting and ending times—the problem is to hook these trips into chains (so that a vehicle arriving at the destination of one trip can begin another if the origin of the second trip is the same point as the destination of the first, and its time is later) while minimizing the total number of vehicles. In some cases of "variable scheduling" there are tolerances on the times; and there may even be costs for deviations from desired times to be balanced against the cost of additional vehicles. It turns out

that these problems are represented by minor modifications of familiar models of scheduling jobs on machines, knowing the time requirements, the precedence relations of the jobs, and the due dates. Stern has formulated his model as a large integer programming problem; he solves it by branch-and-bound methods, which work neatly in this special case because the subproblems are transportation models which are amenable to network techniques.

Meir Rosenblatt, who took his doctorate in the Industrial Engineering Department at Stanford and subsequently taught at Cornell, has worked in capital budgeting, but is now interested in plant layout. This is an area which was of interest to classical industrial engineers and has been largely disregarded by operations researchers because it seemed "old fashioned". Rosenblatt's approach is dynamic: given a job shop which is changing over time, at what point does it become appropriate to change the entire layout?

Alan Stulman took a doctorate in OR at New York University and worked several years in industry in the US before coming to BGU in 1977. He is applying optimal control theory to the quality control of sampling problems. He is attempting to find minimax sampling plans, following some ideas from K. Arrow. Such plans imply an assumption that nature is malicious—in this case, that nature is distributing the pollutant in the material from which we are sampling in such a way as to maximize the variance of our estimate; the minimax idea minimizes that maximum estimate.

Avram Mehrez took a doctorate at Johns Hopkins University in "Mathematical Science and Systems Analysis", working on problems of risky research and development (following seminal papers by Kamien & Schwartz). He is now extending this work, and also working on location and scheduling problems. One of these is the famous problem of the maximum range of a vehicle which carries its own fuel, and advances beyond the last supply point establishing caches of fuel for a single final run. The non-intuitive answer to that problem is that the range is infinite; but there are a wide variety of realistic problems in more complicated contexts. He is working with a colleague, Marvin Hersh, on optimal refueling policies for aircraft.

Hersh took his PhD at the University of Southern California, and works primarily in problems of the aircraft industry. For example, the scheduling of aircraft ground crews (for cleaning the aircraft and the like) is a classical problem. The objective is to minimize the crew size subject to constraints on work, meals, rest, etc As in so many others, the actual application is far different from the textbook one. It is an integer programming problem and too large for solution on a digital computer, so it must be decomposed by finding sets of nonoverlapping constraints. But then the solutions are not realistic for a variety of reasons—for example, the crew sizes vary during the job. It is necessary to apply various heuristic smoothing techniques to account for this.

David Shinar took his doctorate at Ohio State University in psychology and industrial engineering, and then worked several years at Indiana University, before returning to BGU to teach ergonomics. His research is sponsored by the Israeli government, and involves evaluating and recommending licensing requirements for heavy and public vehicles. Basically, the problem is to find a discriminant function which determines the granting or denial of a license to an applicant. They have available data on age and sex, anthropometric and medical data, biographical data and history of accidents, and test results on motor behavior and psychological aspects (various tests, including psychological tests, are now given). The object is to predict who will have accidents and who will not, at least on a statistical basis, and to use these predictions as a guide in the granting of licenses.

Daniel Tabak took a doctorate in electrical engineering at the University of Illinois and has subsequently spent many years at Rensselaer, University of Texas, and NASA's Langley Research Center. He has also spent a lot of time at BGU, both in the Industrial Engineering Department (of which he was head one year) and in the Electrical Engineering Department (where he is at present). He works on multiobjective optimization of nonlinear systems applied to aircraft design, especially the lateral control system of the plane. His publications are largely in control theory and in mathematical programming, and this research project combines both.

Absent from BGU during my visit was Shaul Ladany, presently visiting professor at Georgia Institute of

Technology. Ladany is an extraordinary man who has combined his interest in sports (he was on the ill-fated Israeli Olympic team at Munich and holds the world's record for the 50-km walk) with his interest in OR (he was at one time head of the Industrial Engineering Department at BGU, and has been visiting professor at the Business School at Columbia). He has authored several articles and co-edited (with the author of this article) two books on applications of OR techniques to the determination of optimal strategies in sports.

Enough has been said to indicate that at all of Israel's universities, the qualifications of the faculty and the standard of research in OR is fully up to that of most institutions in the US or other countries. In spite of the low salaries and high taxes, in spite of the barbed wire and the call-ups to active military duty, the OR personnel in Israel are active, outgoing, and effective, and the state of health of the OR profession in that country is excellent. (Robert E. Machol)

OPERATIONS RESEARCH IN ITALY—PART ONE

Like many of the European countries, Italy has in recent years passed a good deal of socialistic legislation aimed at making society more egalitarian. The twenty-odd "Universities of Studies" (which is the official name of each university run by the federal government, constituting most of the Italian universities) have been the subject of much such legislation, designed for example to ensure that some colleges are not better than others (which might give the rich an opportunity for a better education than that which can be obtained by the poor). Among the specific laws passed by the parliament are those which state that all universities must have the same chairs and the same degree requirements. It is easy for an individual university to introduce a new optional course, but very difficult to introduce a new required course. As a result, operations research (OR) does not nominally exist as a chair or a curriculum or a required course in most Italian universities. It is found under that name at Venice, Calabria, and Parma, but more often, as indicated below, under other names.

The principal degree given by Italian universities is the Laurea; it is roughly equivalent to our Master's degree, and is typically won by students at age 23. Anyone who graduates with the degree of laurea is entitled to call himself "Doctor"! While this is not common, it can be confusing to Americans when it is done. There is a bachelor's degree, but it is rarely taken; strangely, there exists no doctoral degree in Italy at this time. The "doctor of research," which was probably somewhat higher than the corresponding American degree, was recently abolished by the Parliament and the new replacement degree has not yet been authorized. Secondary education in Italy tends to end at about 19 years of age, and at the best high schools is probably superior to the education at American high schools, especially in terms of preparation in mathematics and the sciences.

Large numbers of students go to Italian universities, which are easy to get into. The cost is at worst trivial (about $100 a year) and at best negative; that is, if a student stays in good standing by passing a sufficient number of courses, he receives a small stipend, considerably larger than the tuition. A number of students do not bother to obtain this stipend, but remain enrolled at the university, paying the small tuition year after year, signing up for courses and taking the exams with the hope of passing them, and occasionally passing a course or two; and possibly, after many, many years, graduating. This fact, that not all students enrolled at the university are seriously pursuing full-time studies, should be borne in mind when the numbers of students enrolled are mentioned, particularly at the University of Rome, which may be the largest in the world with over 150,000 students enrolled at this time. Each of the major cities has a university of studies, bearing that city's name; one university of studies (Calabria) bears the name of a region (comparable to a state in the US); and there are a few private universities in Italy, mostly run by the Church.

Each university is divided into faculties (like schools in the US) and each faculty into institutes. An institute was formerly a single chair, but now may contain several chairs, like a small department. OR is found in a number of different faculties and institutes, as will be seen below. The number of chairs in Italian universities is growing explosively. As of the beginning of 1980 there were 4,000 chairs, many of which were added quite recently. Another 3,600 will be added this year, 2,500 more the following

year, and probably additional ones in the next 2-3 years before the total levels off at about 16,000. Each of these chairs is advertised and competed for. The 3,600 chairs to be added in 1980 are divided into 353 groups, one of which is in "operations research and general mathematics"; 11 chairs are being offered in this group and there are 140 candidates for them. Most of the young men active in OR in Italy are competing for these chairs, which were a significant topic of conversation at most of the universities I visited. The winners will be assigned to specific chairs at specific universities, but after about a year they will be free to go to the university of their choice, and such transfers are usually obtainable without too much difficulty.

While publication is the primary criterion for awarding chairs, there seems to be less pressure to publish among those who already hold chairs. In particular, since there is no doctoral program, one cannot assign interesting problems to doctoral candidates. Furthermore, joint publication is quite rare in Italy, at least in OR. The OR research output of the country is less than one might expect.

The remainder of this pair of articles is devoted to a brief description of the Italian OR Society, followed by discussion of OR at a number of Italian universities.

AIRO, the Italian OR society, has about 400 members of whom more than half are academic, the latter including students. AIRO publishes a journal with many of the articles in English and with every article having a summary in English. Many of the articles in this journal are written by nonItalians, including large numbers from Greece and India. The journal is not considered very prestigious in Italy, and some of the best Italians in the field publish by choice in the *European Journal of Operational Research*.

I talked with Massimo Merlino, vice-president of AIRO, a young dynamo who took a laurea in chemical engineering in Genoa and then spent 2 additional years in the economics faculty (which would have justified his obtaining a second laurea although he did not bother to get the degree). His chemical-engineering thesis was on linear programming in oil refineries, and he worked for several years in an oil company before becoming a partner in Praxis Management, a consulting firm, a few years ago. The firm has about 50 people of whom 7 are in OR (most of the 50 are in software) and is headquartered in Milan.

Merlino told me flatly "There are no OR applications in government in Italy," but there are some exceptions to this: the military has some OR work (but there are only about 5 OR people in each of the 3 services); and many of the regions are now organizing planning-study commissions to take care of new roads, communication and transportation networks, airport location, etc, and there are OR staffs on some of these commissions. Still, what OR there is in Italy is mostly in industry. OR was brought to Italy in 1960 by multinational steel and oil companies, and during the 60s most of the large companies (such as Fiat and Olivetti) set up OR groups of 5-10 people. These were mostly disestablished in the early 70s because they were not considered profitable, or because the available money was put preferentially into computers and software rather than OR; but mostly because "people" (industrial relations, union matters, and the like) were given first priority. Somehow or other it was felt that the quantitative approach was inhuman, "reductionist," ignored human factors, and in general was "fascistic." "Everyone in Italy", said Merlino "prefers the pragmatic or the psychosociological approach to the quantitative approach. Implementation is never taught in universities." Actually, Italy has virtually no resources of minerals or energy, and more than 60% of the cost of everything that they export is in the materials (which must be imported). For these reasons, in this context the Italian problem is really not one of people, but one of materials and of risk. As this is being realized, OR is making a comeback, but generally not under that name. "Management science" is acceptable, "logistics" is quite popular, but most important are computer-related terms such as electronic data processing (EDP) and management information systems (MIS). "Four years in OR is not so good as a 15-day course in COBOL" Merlino told me.

Nonetheless, extremely good work has been done; for example, Alitalia has a complete package (including software) on various kinds of OR and the like which has been sold to a number of other organizations; in particular the Saudis paid $6 million for it. MIS and EDP have grown very rapidly. IBM's growth has been 25% per year with no saturation evident.

Merlino told me an anecdote from his consulting practice about building a simulation model for balancing a new

production line for refrigerators. A principal conclusion of the simulation was that a large amount of warehouse space would be required; but an insufficient amount of warehouse space had already been committed and it was too late to make any changes. Merlino felt that in some ways this kind of misuse of OR was typical of Italian industry. He also told me of going to ENI (the national petroleum company) and building a model of the refining system of Italy (40 refineries) with emphasis on how to handle a crisis in supply. When the energy crisis came in 1973, the model worked. This is the kind of thing which eases one's entry for further OR projects.

ROME

At the University of Rome, OR is taught in the Institute of the Calculus of Probability in the Faculty of Statistics, and in the Institute of Automatics in the Faculty of Engineering. The head of the former institute is Prof. Giorgio dall'Aglio. It is a large institute (there are three other chairs) and dall'Aglio is primarily an administrator; while his research interests are in stochastic processes, he has not published in recent years. Of particular interest in this institute is an unusual post-laurea course of two years resulting in a "diploma of specialization in operational research." About fifty students enter this course each year and about 1/3 of them manage to graduate at the end of the second year. The course is not unlike the MSc in OR given at many British universities (*ESN* 32-12:427); although there is a lot more theory here, there are some "laboratories," and students do work on supposedly real problems though actually these are mostly textbook problems and the students work on them in groups.

Different faculties in the same university in Italy tend to be in quite different locations. The Engineering Faculty of the University of Rome is far from the Faculty of Statistics; it is in fact in the shadow of the famous Colosseum. The dean of this faculty, Mario Murgo, is an electrical engineer who has long been interested in the control of electrical machinery and who takes particular interest in the Institute of Automatics, which is headed by Prof. Alberto Isidori. While the Institute is primarily interested in control theory, there is also some instruction in OR. Isidori's research interests are in nonlinear control problems and the theory of disturbance decoupling and pole placement. He is interested in the applications of differential geometry to the feedback control of nonlinear systems as a substitute for describing functions. This appears to have been rather successful in synthesizing systems which decouple incoming disturbances from the output. The solution is related to known solutions for linear systems and involves synthesis of a classical linear system using similar techniques.

One of the more interesting people in this institute is M. Lucertini who has two full-time jobs, one with Isidori and the other at the Institute for Systems Analysis and Informatics of the Italian National Research Council (NRC). For this he gets paid 1.5 salaries—very few professors in Italy attempt to live on the university salary alone, since that is not very large. It turns out that such moonlighting is quite feasible, since the requirements for a university professor are not very demanding. At minimum he should teach at least 1 hr per day on at least 3 different days; but there are exceptions even to this modest regulation; we note below one instructor who teaches two days a week at each of two universities 100 miles apart.

Lucertini teaches an OR course to junior-year candidates for the laurea; about 120 students attend the course. The text is an Italian book by Sergio de Julio (see below), which he told me is similar to the well-known American text by Hiller and Lieberman but somewhat more mathematically oriented. At the NRC Lucertini is head of the mathematical programming group with particular interest in integer programming. This group has close connections with a number of groups in other countries, including the group in Warsaw run by Walukiewicz (*ESN* 34-3:146). Lucertini's speciality in integer programming is methodological, involving specifically certain group-theoretic approaches. Lucertini's group also does applied research. They have recently completed the design of a logistic support system for Italian electronic firms such as Selenia which manufactures radars. Selenia gave them money for this contract. Another sponsored contract is on air traffic control. Such control is presently performed by 3 large (IBM 370) computers working in parallel. They are trying to arrange to do it with microcomputers, and to design an appropriate local network of computers. Such dedicated computers give quicker response and higher reliability. The problem is

how to decompose the functions. Working with the Italian equivalent of our FAA, they are well along with their studies and plan to implement the program next year.

CALABRIA

Sergio de Julio struck me as outstanding. He has his laurea in electrical engineering from Naples and his doctorate in engineering from UCLA under A.V. Balakrishnan. When he returned to Rome in 1971, there was no OR taught at the university there. When he went to Calabria (at the toe of the boot of Italy), he began to teach OR there. As indicated above, he has written an Italian textbook on OR, and has continued to teach, even when he was dean of the engineering faculty there, and even now when he spends very little time at the university because he is president of a consortium. The consortium was created to set up major research projects since it is very difficult to work within a university structure because of bureaucracy and the low salaries. The consortium is run by the University of Calabria, a local bank, some private industries, and the NRC. The consortium is interested in computer-related subjects and also in systems theory. De Julio's personal research has been in the latter area, and in particular in the optimization of distributed-parameter systems: given a system described by partial differential equations, and given a target function, the problem is to find an input which will force the output to be as close as possible to that target function. De Julio explained to me that this is entirely analogous to linear programming, except that the constraints are in the form of partial differential equations. Currently, de Julio is working in nondifferentiable optimization and combinatorial programming.

Another fascinating man was E. Aparo, an old-timer who gave the first OR courses in Italy more than 20 years ago (at the ministry of post and telecommunications in Rome). A real scholar, specializing in the field of numerical analysis, he was in the US in 1951-2 working on the very first computers—SEAC in Washington and UNIVAC in Philadelphia. On his return to Italy, he introduced computer programming at the university level, and supervised the installation of Italy's first large computer at the NRC. He has taught OR at a number of universities, and at the postgraduate schools of several large industrial firms. Presently he is professor of Mathematics for Biologists at the Faculty of Science of the University of Rome. His current research interests concern mainly nonlinear programming and its applications. He is working on an interesting combinatorial problem suggested by Leo Moser: how two dice should be loaded so that on throwing them, the probability of the most probable sum is as small as possible. This problem can be generalised and translated into a problem of nonconvex nonlinear programming. Further research is conducted on the identification of fixed points by means of methods of combinatorial topology.

SIENA

I mentioned in these pages (*ESN* 33-9:339) an outstanding research paper by Giacomo Patrizi formerly of the University of Calabria. He now teaches at the University of Siena, 100 miles north of Rome, in the Institute of Technical Economics in the faculty of Economic Science and Banking (i.e., finance), and at the University of Bologna, another 100 miles farther north, in the Institute of Administration in the Faculty of Politics (i.e., public administration). That he can teach at these institutions while maintaining his residence in Rome says a good deal about the Italian educational system. He teaches 3 hours on each of 2 days at each of these two institutions, and for this collects 1.5 salaries. The federal government does not permit a professor to collect two full-time salaries for two jobs.

Patrizi took a master's degree in economics at Trinity College, Cambridge, and a PhD in Economics at Georgetown University. He has recently published a book (in Italian) on long-range planning, and because he considers long-range planning as an optimal control problem this has led him into research on nonlinear optimization. He has developed an algorithm for constrained nonlinear programming which uses generalized inverses and about which he is very enthusiastic. Long-range planning leads to large sparse matrices for which this algorithm is particularly good. If the objective function is quadratic and the constraints are linear the algorithm converges in one iteration; and in general if there are n variables and m constraints with $n >> m$, then it converges in n-m iterations.

Siena is a lovely old medieval fortified city on a hill, and the Faculty of Economic Science and Banking

is located in a lovely old monastary at the very top of this hill. The director of the Institute of Technical Economics is Antonio Pin, who is not himself an OR man. Patrizi teaches a course entitled "Managerial Statistics and Analysis of Markets" which he makes into a course in modeling and identification. This is very much in the spirit of the modern American theories of marketing, as taught for example by J.D.C. Little at MIT and by P. Kotler or A.A. Zoltners at Northwestern. The OR course is taught to 10-15 students a year by Luigi Tomasini, who is interested in decision-making and plans to publish a book on the theory of decisions, in which he emphasizes philosophical rather than quantitative techniques. His present research is connected with the fair division of pollution rights in economics. He has developed a theory of "bads" analogous to the usual economic theory of "goods": people should bid against one another for the right to pollute, up to whatever level the government feels is safe; and those who lose this bidding war should be forbidden to pollute but should be given some appropriate side payment. He is also interested in the optimum choice of reward levels in an organization, following work done by Marschak—it is worth noting that in Italy, as everywhere else in the world, economists and OR workers are familiar with what is being published in the US.

BOLOGNA

At the University of Bologna operations research is taught in several different faculties. Patrizi teaches a conventional OR course in the Institute of Administration in the Faculty of Politics. This Institute is headed by a remarkable man, Prof. G. di Federico. He spent a year at the London School of Economics and then several years at Michigan State University where he completed all but the thesis requirements for the doctorate. This was followed by a year at the University of Michigan, working on mathematical logic. His personal area of research interest is the organization of the judiciary. He plans to set up in his institute something very much like a school of management. It is virtually unique in Europe to have such a school, especially one with an emphasis on quantitative methods, in a faculty of politics. He will insist that all of the students take basic courses in operations research, statistics, organizational planning, methodology of social science, and "the relation of evidence to inference," a favorite topic of di Federico's.

In the Faculty of Engineering (which is on the opposite side of town from the other faculties) I talked to Prof. G.C. Barozzi, head of the Institute of Applied Mathematics. There are nearly 20 faculties of engineering in Italy and most of them have institutes of applied mathematics, but strangely, OR is rarely taught in such institutes. At this institute Barozzi is primarily interested in numerical analysis with applications to filter design, to the design of signals, and to estimation in econometric models. OR is taught in this faculty in the Institute of Automatics whose director is Prof. Sarti. In this institute, I talked with Paolo Toth and Sylvano Martello, the former a full professor and the latter an associate professor. They both prefer the title Ing. (for engineer), while G. Carpineto, also an associate professor, prefers the title of Prof. He teaches the formal OR course to last-year students in engineering. About 150 students take the course each year and about 90% of them pass. It is a very intensive course, taught out of an Italian translation of Hillier and Lieberman, with a total of 60-70 hours of lectures in the period October-February.

The research of all three of these people is similar; and while they called it OR, it seemed to me more like software development. They work on problems like the generalized assignment problem and the bottleneck traveling salesman problem (both are NP complete), developing algorithms based on branch-and-bound methods and then writing software and debugging the programs on the computer. They have an extensive list of such publications (one of them is joint with Prof. Nicos Christofides of Imperial College in London, a fine scholar whose interests, in general, are much broader). They have also recently published a large book on combinatorial optimization, which was actually the proceedings of a summer school on this topic. Finally, they have organized a permanent seminar (of which Martello is the secretary) on combinatorial optimization involving 25 people from 7 Italian universities, including among those mentioned in this article Lucertini (see above) and Simeone (see below).

Also at Bologna, I met a fascinating man, Prof. Giorgio Basevi, professor of international economics, director of the Institute of Economics in the Faculty of Politics, and director of Prometea, an independent nonprofit organization for economic forecasting. Basevi's office was in an old building with elaborately frescoed walls and cherubim all over the ceilings, reminiscent of the Sistine Chapel. It is remarkable to me that in such an office one can concentrate on mathematical models.

Basevi, who took his doctorate at the University of Chicago under Milton Friedman, started to work some years ago with Lawrence Klein of the University of Pennsylvania, who had developed a project called LINK in an attempt to link econometric models of various countries. Basevi and his coworkers, including Angelo Tantazzi and Guido Gambetta, built a model of the economy of Italy which has been used by Klein and run twice a year in Philadelphia with a number of other models as a part of a large simulation and global forecast.

About 5 years ago they decided that there was too much bureaucracy at the university and so a group of economists and econometricians formed Prometea as a nonprofit organization. As it was set up, this institution is owned by its clients (of whom there are about 60, including most of the major corporations of the country) and Basevi and his colleagues get only a modest fee. This seems unfortunate, because the organization has been extremely successful. They run short- and medium-range forecasts (up to 3 years ahead) using a standard Keynesian model. This is one of only two such forecasting models in Italy (the other is by the Bank of Italy, and they do not publish theirs).

This article will conclude next month with reports of visits to research institutes and universities in Pisa, Florence, Padua, Trieste, and Milan. (Robert E. Machol)

PHYSICS

THE INSTITUTE OF PHYSICS

Upon arriving in a foreign country, a physicist might wish to make contact with the local national physical society. In England, this is The Institute of Physics. Its headquarters are at 47 Belgrave Square, just a short walk from the Hyde Park underground station. This beautiful regency building houses a staff of approximately forty people, including porters, receptionists, and part-time workers. As is the case with many places in the UK, gaining entrance to the institute is a more formal procedure than it would be in the US. One does not just walk in; or rather one may, but one does not get very far. British procedure is to make an appointment. After I had made the necessary appointments, my interviews with the education officer M. Ebison, and the meeting officer, C. Jones, produced the following information.

The Institute of Physics has its origins in The Physical Society, founded in 1874 as a learned society, whose relatively small membership was drawn primarily from academic physicists. The institute was founded in 1918, by members of the Council of The Physical Society, to undertake programs concerned with physics as a profession. Growth of both the institute and the society was gradual until after World War II, when they expanded dramatically. In the postwar years a growing sentiment held that the institute and the society should be combined. This was accomplished in 1960 and formalized in 1970 by the grant of a Royal Charter, which gave the combined organization the name of The Institute of Physics. Partially as a result of this amalgamation, several categories of membership exist, including such designations as "members of the former physical society." However, it is expected that in time there will be three catagories of membership for the graduate physicist. In increasing order of distinction these are: member, fellow, and honorary fellow.

Approximately half the physicists in the UK are members of the institute. These, combined with the 4,000 overseas members give a total of approximately 16,000. The Institute of Physics includes all branches of physics except acoustics, for which a separate organization exists. Until recently, The

Acoustics Institute also was located at Belgrave Square but it has moved to the University of Edinburgh for reasons of economy. The Institute of Physics is divided into 22 specialty groups, any of which a member of the institute may join upon payment of an annual fee. The institute holds no general meetings; instead, meetings are held at the instigation of the officers of a particular group. As a result, all meetings in the UK are speciality meetings.

Journals published by the institute that are well known to Americans are: *The Journal of Physics A Through G, Reports on Progress in Physics,* and *Physics in Medicine and Biology.* Since 1979, the institute has aquired one half interest in *Plasma Physics* which is published in conjunction with Pergamon Press. Less well known are *Physics Bulletin, Physics Education,* and *Physics in Technology.* The latter is an interdisciplinary magazine with the stated purpose of expounding applications of physics to current technology. *Physics Education* is a magazine for teachers at all levels: high schools, colleges, polytechnic schools and universities. A recent issue contains articles on laser-driven fusion, computer solution of the Schrödinger equation, and a description of Prestel—The British Post Office's newest view data system. *Physics Bulletin,* like its American counterpart, *Physics Today,* contains a section entitled "news and comment", short articles, book reviews, and, more importantly for the visitor, an occasional listing of meetings.

Education is an important function of the institute. Part of the program of aquainting young people with physics and physicists includes articles in *Physics Education.* One of the recent issues is devoted to university entrance and choice of a career. This issue also lists the courses in physics at 145 different institutions in the UK. This listing is one aspect of a major difference between the US and the UK. In the UK, The Institute of Physics has official authority and responsibility for certifying physicists. High-school-level examinations and graduate examinations are monitored to ensure that they are of proper and uniform level. In addition, the university courses and programs are regularly inspected. Another difference is the research organization owned by the Institute of Physics since 1965. The Fulmer Research Institute Ltd. consists of a group of five divisions with facilities located peripherally about London. The entire company employs approximately 250 people of whom over 100 are professionals. In 1978 the income from contract research and development with government and industry was over £2.5 M.

Finally, there is the question of what the institute can do for a visiting foreigner. For the casual visitor, the institute serves as a point of initial contact with Britain and Europe, since the institute is also a member of The European Physical Society. One can go to the institute headquarters (remember to make an a appointment) and obtain a membership list and a listing of the officers of each of speciality group. However, a listing by geographical location is not available. The more interested visitor may join the institute at the proper level depending on qualifications and avail himself of all its benefits including the *Physics Bulletin* on a regular basis. (John R. Neighbours)

LASERS (MIDGETS & GIANTS) AND OPTICS AT RSRE

Since the beginning of my assignment at ONR London in January 1979, I have wanted to visit with those involved in laser R&D at the Royal Signals and Radar Establishment (RSRE). However, I was told that the Baldock, Christchurch, and Malvern laboratories were being amalgamated into one facility at Malvern, and that it would be best if I waited until this process had been completed. In January it was thought that a July visit would be good, in July I was told that the changeover should be completed by December, and in December—. In March, with the amalgamation nearly accomplished, I was hosted by Dr. A.L. Mears, superintendent of the Laser Devices and Techniques Division. I was delighted to find that Mears was not only an able technical leader, but also very much aware of the UK policies impacting the support of research and technology. In the following paragraphs the reader will find discussions on RSRE's sources of support, the organization and task areas within the Physics Group, and laser and optics R&D projects in Mears' division.

Four of the seven top-level divisions of the Ministry of Defence (MOD) are the three service organizations (the Admiralty, Army, and Air Force Boards of the Defence Council) and the Procurement Executive (PE). All of MOD's 12 laboratories, called Establishments (e.g., RSRE), are organizationally under and principally funded by the PE. The salaries of the laboratory personnel are provided by the PE based on laboratory personnel ceilings rather than in response to proposals for specific tasks. Among the advantages of this scheme of personnel funding are the reduced fiscal responsibilities of the technologists—reduced, that is, as compared to the fiscal load of US Navy laboratory technologists who must "hustle" for their salaries. It appears to me that the MOD Establishments' technologists should therefore be able to dedicate a larger percentage of their time to their "real work", i.e., technology, than can their US Navy counterparts. Mears stated that another result of the Establishments being under the PE is that they have considerable freedom from short-term pressures from the services. This is important, because the services in the UK are less engineering oriented than in the US.

The freedom from short-term pressures is certainly not accompanied by a total lack of guidance from the PE. Mears said that the section of the PE responsible for the Establishments (the 3 deputy controllers for R&D Establishments and Research, and their staffs) is indeed comprised of scientists/technologists, who provide technical guidance.

Even though each of the Establishments is under the control of one of the deputy controllers (Admiralty, Army or Air Force) at least three are in essence tri-service, e.g., the Admiralty's RSRE, the Army's Propellants, Explosives and Rocket Motor Establishment and also the Army's Royal Armament Research and Development Establishment. The assignment of most of the other Establishments to a specific deputy controller are considered to have been made arbitrarily, and work often cuts across the services.

The major portion of MOD's in-house applied research in lasers and optics is conducted at RSRE. The 1500 scientists/engineers of the RSRE are apportioned among 6 groups and the laser/optics work is carried out mainly in the Physics and Optics Groups. The Physics Group, the largest at RSRE, has close to 150 professionals and is divided into 4 divisions. These are the Solid State, Signal Processing, Laser Devices & Techniques, and Materials Divisions. The 10 theoreticians within the Physics Group are not tied to any specific division in that they work wherever their expertise is required.

The Solid State Division is involved primarily in microwave and millimeter-wave-device and materials development and assessment, and in the development of displays. Charge-coupled devices, surface-acoustic-wave (SAW) devices, and large-scale integration fall within the charter of the Signal Processing Division. This division expects to be involved in very-high-speed integrated circuit development in the near future. A report covering RSRE's involvement in display technology, microwave and millimeter-wave devices and materials, and signal processing will be presented by I. Kaufman in *ESN* within the next few months.

The Materials Division produces high-quality materials for all of RSRE. Among these materials are III-Vs, Si, those used for surface acoustic wave devices, and insulators. Because the British Post Office is developing semiconductor injection lasers, and inasmuch as the Materials Division works closely with the Post Office, RSRE is not doing any injection-laser-material work. A report on this division has appeared in these pages (*ESN* 31-12:494). The remainder of this article describes some of the projects within Mears' division.

The laser endeavors of Mears' division center around CO_2 as the active medium. As they have developed lasers ranging in size from waveguide lasers to those of the 1 kJ variety, the similarity of these lasers virtually stops with the gain material. Their waveguide lasers are sealed and are fabricated from alumina. Output powers up to 4 W cw have been realized from a 15-cm-long active region. When the laser was operated in the pulsed mode, a peak power of 20 W was obtained with a prf of 10 kHz. Acoustooptic modulators, used externally to the resonant cavity, have been employed in the development of a waveguide cw hetrodyne laser rangefinder. The modulated signal was in the form of a chirp (sawtooth frequency modulation); I assume it was a linear chirp.

On the opposite end of the size scale, Mears' division has been involved in the development and use of large laser devices. Two of these, although they were developed some time ago, are mentioned here. The REP 3, an e-beam sustained, closed-cycle recirculating laser, was designed and built by the Laser Devices & Techniques Division at Baldock. The design of the power supply was a joint venture between the Establishment and Marconi Research Laboratories (Great Baddow, Chelmsford); Marconi is responsible for its construction. This laser is capable of producing pulse energies of 500 J/pulse at 66 Hz and up to 600 J/pulse at a reduced repetition rate. The maximum burst energy observed (though the laser was not pushed to its limit) was 30 kJ in 1/2-1 second bursts. The realization of burst energies of this magnitude in a recirculating laser, as opposed to a blow-down laser, was significant. This laser was used to study laser-damage effects in a variety of materials ranging from metals to insulators. Investigations of laser medium perturbations, induced by laser action itself, are underway; these studies make use of a laser built in the early 1970s. This e-beam sustained laser produces 1 kJ pulses up to 100 ms in duration. Investigators have found, for pulses of equal energy content, that the longer the pulse, the worse (optically) the medium becomes.

Rangefinders designed for use on fast-moving targets must have higher pulse repetition rates than are available from currently used units based on solid-state gain media. A closed-cycle CO_2 laser operating up to a few hundred Hz, and in between the two classes of lasers described above in size, is being developed at RSRE. The laser's gain length is 10 cm, and it produces 30 ns pulses of 1-4 MW peak power at a rate of 100 Hz. The laser-optical-component technology required to avoid (minimize) accumulative damage for 10^8 pulses is under development. They have obtained 10^6 pulses before significant loss of output power was observed.

I had an interesting discussion with Dr. G. Perry on the fast-growing field of optical bistability (*ESN* 33-12:535). He said that because switching times of the order of picoseconds may be possible in devices that exhibit optical bistability, he would most likely start working in this area in the near future. Perry will probably collaborate in some way with the Physics Department at Heriot-Watt Univ., Edinburgh, which, rather recently, has made significant contributions in optical bistability (*ESN* 34-4:203). (Not long ago, Dr. D.A.B. Miller, a research associate at Heriot-Watt Univ., told me that an experimental determination of the switching speed of an InSb crystal should commence in the very near future.) Perry has had an interest in a wide variety of light-scattering processes including scattering of polychromatic light from rough surfaces (and the resulting speckle pattern), steller scintillation (an effect produced by the scattering of light from refractive index variations in the Earth's atmosphere), and the more general topic of light scattered by a random-phase screen. A phase screen is defined as a region of space containing refractive index variations which cause fluctuations in the phase of electromagnetic radiation propagating through it. He has published papers on each of these topics and one may be of interest to a large percentage of *ESN* readers. Entitled "The Twinkling of Stars," it contains an excellent review of theoretical and experimental works on stellar scintillation (*Contemp. Phys.* 19, 127 [1978]). His most recent publication presents measurements of first-order statistics and temporal correlations of intensity fluctuations in stellar images and in the pupil plane (*Optica Acta* 26, 563 [1979]).

Perry and Dr. P.N. Pusey, who also has an interest in scattering phenomena, have co-authored a number of papers on this topic. In one set of experiments, they have observed that the probability distribution of fluctuations in the intensity, P(I), of laser light (633 nm) propagating through atmospheric turbulence is well described by a log-normal distribution for propagation distances $\leq$ 200 m. For ranges of 500-700 m, P(I) follows the K distribution, and at ranges between 200 and 500 m P(I) falls between the log-normal and K distributions. The K distribution, which was "invented at RSRE," is described in terms of Gamma and modified Bessel functions. A discussion of these distributions and a comparison of the experimental results obtained with them are presented in "K Distribution in Atmospheric Propagation of Laser Light" (*J. Opt. Soc. Am.* 69, 796 [1979]).

The morale of those investigators with whom I talked was high and Mears said that because this was generally true of Baldock personnel, few dropped

from the rolls as a result of the move to Malvern. The enthusiasm within Mears' division and the end of disruptions due to the amalgamation of the laboratories should lead to a resumption of the high productivity typical of RSRE. The combination of technical discussions and insights shared on the "workings" of MOD and the Establishments made the day spent at RSRE most enjoyable and informative. (R.S. Hughes)

PSYCHOLOGY

AN AGARD MEETING ON SLEEP, WAKEFULNESS, AND CIRCADIAN RHYTHM

The Advisory Group for Aerospace Research and Development presented Lecture Series Number 105, entitled "Sleep, Wakefulness and The Circadian Rhythm," on 1-2 October 1979 in London. The presentations covered the following subjects: (1) The physiological bases of sleep, wakefulness, and circadian rhythm and their psychological correlates, including performance of personnel involved in skilled activity; (2) Adaptation of man to disturbed sleep, circadian rhythmicity, and unusual patterns of rest and activity; and (3) Management of disturbed rest, irregular rest, activity and rationality by the use of drugs.

The series was designed for those concerned with the management of civilian and military personnel, especially the latter, who have to cope with irregular work and rest in land, sea, and air environments. The purpose of the presentations was to provide an understanding of the physiological processes involved in the adaptation of man to disturbed sleep and wakefulness, and to consider approaches to the problem of management, including the use of drugs. While it was intended that the 117 participants should include chiefly managers, operational staff, and medical officers, it was obvious, both from the roster of attendees and in the questions elicited from the floor, that a large number of research personnel were present, many of whom were not primarily medically oriented.

I found the presentations comprehensive, well-organized, and, without exception, marked by research expertise as well as sophistication in each of the topic areas covered.

I was most impressed with two American presentations: "Sleep Disturbance and Performance", by Dr. L.C. Johnson (US Navy Regional Medical Center, San Diego, CA); and "Biological Rhythms of Man Living in Isolation from Time Cues", by Prof. E.D. Weitzmann (Department of Neurology, Montefiore Hospital Center, New York).

Johnson's work was based upon extensive experimentation, observation, and analysis of sleep patterns and habits of US Navy crews and their subsequent performance. As an example, he was able to demonstrate that good sleepers and poor sleepers could be differentiated with respect to quality of performance in school and assignment, sick-call frequency, reenlistment records, and attrition. He had some tentative evidence that virtually all the poor sleepers he studied smoked cigarettes, while the good sleepers did not. In addition, Johnson observed that the good sleeper controls his sleep; he goes to sleep when he wants to.

To demonstrate "the lawfulness of biological rhythm functions in man," Weitzmann established a laboratory situation in which one subject at a time (10 males in all) was cut off from cues of time over a 3-month period. He was not isolated from all people in that he saw staff members, but he had no contact with relatives or friends except through mail which was delayed at random intervals. He was initially led to establish his natural sleep pattern over several days, then was obliged to keep to that pattern for several more days; for the balance of the experimental period he was on "free run" to follow his own pattern, with one stipulation—he could take no naps. Sample findings (confirming previous research) were that human biological rhythms run freely for periods greater than 24 hours; typically, approximately 25 hours, but with considerable individual variability, and after an extremely variable period of free-running, many normal humans settle spontaneously into "long" biological days (35 hours) often alternating with "short" days (approximately 25 hours).

The managerial implications of these research efforts can be widesweeping. Johnson believes military managers have already conceded, or are ready to concede, that sleep disturbances connected with performance are not necessarily disciplinary matters but may be problems that should be referred to health authorities; e.g., sleepers on duty—even guard duty—are now sometimes recommended for remedial health action rather than for a court martial.

The following additional findings were reported in the various papers:

(1) On reaction-time tests, those given placebos perform better than those given hypnotics—usually because not enough initial consideration has been paid to predicting after-effects of the hypnotic. In fact, there was a tendency to report that many clinical cases of hypo-insomnia were improved by removal of previously prescribed (presumably mal-prescribed) hypnotic doses.

(2) Where long hours of performance, interspersed with naps, are required outside the normal sleep pattern, short naps are better than long naps for overall performance.

(3) It is not the type of sleep, but the amount of sleep, that is important for performance; e.g., REM sleep is not better than other stages of sleep. (There was considerable agreement on this point.)

(4) The time of sleep may be an important factor in performance; some people are made to work when they should be sleeping. With others it apparently makes no difference. In other words, some people can tolerate shift work better than others. However, little progress has been made as yet on operational recommendations.

(5) Navy aviators with more fragmented sleep made more errors than those with unbroken sleep, although both groups had the same amount of sleep.

(6) It is not clear from research whether exercise influences sleep.

(7) Poor sleepers had higher oral temperatures at bedtime than good sleepers, but once they fell asleep there was no temperature difference and no difference on arising.

(8) Apparently there is an optimum amount of sleep required by each individual. Long and short sleepers have been shown to be equally effective in performing similar tasks. Also, when the length of sleep was forcibly increased for short sleepers, performance deteriorated.

(9) Insomniacs report less sleep than they actually get as measured in the laboratory.

(10) Noise *per se* as a source of sleep disturbance is a confounded research variable; discrepancies in noise levels and the meaningfulness of noise, e.g., infant crying, need to be exam examined.

(11) Light of day is believed by some to be a critical factor in circadian rhythm but this factor is questioned by others.

(12) It is difficult to establish a significant relationship between sleep quality (good versus poor sleep) and performance. The "fault" is motivation: the extra efforts performers make to compensate for fatigue and other troughs in physiological states. As Bryce Hartman (USAF School of Aerospace Medicine) reported (after examining one piece of fragmentary data involving pilots and varying missions times), "This (the data) suggests that the circadian stressor impacts performance (overcomes compensatory mechanisms) only after a significant degree of fatigue is present."

Studies carried out on healthy men provide some guidelines for the occasional use of hypnotics in the management of sleep when impaired performance the next day would be unacceptable. The prolonged effect of commonly used drugs, which I call (a) and (b), suggests that some compounds are more appropriate for the management of insomnia where anxiety is not important. Other drugs (c) and (d) are more appropriate in the management of disturbed sleep when a residual anxietal effect is to be avoided the next day. Moreover, (c) would appear to be particularly useful for sleep at unusual times of the day.

The foregoing are highlights of the performance aspects of the lecture series, as they impressed me. (Arthur J. Drucker, US Army Research and Standardization Group, Europe)

SCIENCE POLICY

DUNCAN DAVIES—A ROGUE ELEPHANT WHO SACKS LIBRARIES

The British Cabinet has 24 members, 15 of whom have the title "Secretary of State"; and just as each American cabinet officer has an Assistant Secretary for R&D or something equivalent, so seven British Cabinet Ministers have a "Chief Scientist," although in some departments he may have a different title, such as "Director General of Research" or "Chief Scientific Adviser." Unlike the US, where the Assistant Secretary is a political appointee, the Chief Scientists are civil servants, and are not replaced when the government changes. They differ in another important respect: most of the western countries have a spokesman for government technology such as Frank Press (science

advisor to the President of the United States), Volker Hauf (federal minister for research and technology in W. Germany), or M. Aigrain (Minister of Research in France). In the UK there is no technology policy for the government as a whole, and each Secretary of State has his own.

I talked with Dr. Duncan S. Davies (pronounced Davis), Chief Scientist for the Department of Industry, who is one of the most important people in the country for setting technology policy for the UK, in part because so many technology issues arise in industry, and in part because he is responsible for six national laboratories, including the National Physical Laboratory (NPL) (*ESN* 34-1:35). Dr. Davies calls himself a "defrocked chemist." He took his doctorate under the famous Cyril Hinshelwood and worked for 33 years for ICI, the British analog of DuPont—for many years as general manager of corporate research and development. He started our interview by telling me "I must build libraries so that I or others may sack them later." He was referring to the library in Constantinople where most of the great scholars in the world had accumulated. When the Saracens sacked this library in 1453, these scholars spread all over the western world and were the prime movers in generating the Renaissance. Davies also told me that he was "an amiable rogue elephant" and that he "had been appointed in order to stir things up so as to get better value for the taxpayer's R&D money."

Davies is struck with the fact that every country has problems with technology policy, and he does not believe that there can be a permanent, monolithic national policy. He stressed the frequent contradictions between the political flavor of what is done in technology and the overt political stance of the country. Thus, he said, in France the posture is to liberalize competition—for example, they allow bankruptcies in important cases (I assume that he meant to contrast this with Great Britain where large companies which get in trouble tend to be subsidized to avoid the loss of jobs that bankruptcy would entail). Nonetheless France is more effectively nationalistic in its technology than any other country in the world; for example there are very few Japanese cars in France, which results in France having a larger market share for its own cars and therefore a lower cost. Market share, in Davies' opinion, is absolutely fundamental in technology policy. Another example is US emission controls on automobiles. These now function partly as a non-tariff barrier against competition from some foreign automobile manufacturers. The Germans and Japanese are seeking to meet these regulations, but in general the French may not try so hard; they will concentrate on selling to the rest of the world, and may also restrict entry of American cars into France. On the other hand, the French have specifically avoided any emission regulation which will disable the "deux chevaux", the famous stripped-down 2 hp car manufactured by Citroen which is the French poor man's chariot.

Davies told me about the Rothschild System, named for Victor Rothschild, the Cambridge scientist who was the head of the British Policy Review Staff, a "think tank" of the 1970s. In the old days good things happened if one simply had sensible people working on sensible programs. A generation or two ago the entrance fee for a major new product such as a car, a plastic, a fiber, or a drug (covering the cost of research; product, process, and market development; hazard and environmental control; and plant investment) might have been a few million pounds or less. Today it may be over a hundred million. There must now be a mission orientation (mission in this context means market) backed but not dominated by good scientific orientation. There must be an appropriate balance between science, market, and resource availability. Following the Rothschild theology—upgrading of market orientation—it is now necessary to devote a progressively greater percentage of the R&D effort to overcome the resource constraints: fuel economy, alternative raw materials, etc. Since the government does not have a clearly measurable motive (profit), it was able to keep a science orientation longer than private industry, but today even the government needs the definition of purpose by a customer—or if there is no customer, as frequently happens in government-sponsored things, then there must be some appropriate proxy for a customer.

In some sense, Davies wears three hats. He is the scientific and technical advisor for the Minister, which though it is his most important job, only commands a fraction of his time

and the time of a very small portion of his staff. His main functions are as a customer and as a contractor. As a customer he runs a series of "requirements boards" in the department. There are requirements boards for chemical and minerals; for computers, systems and electronics; for metrology and standards; for ship and marine technology; etc. Sometimes he acts directly as a customer; while Britain spends much less on space-flight hardware than France or Germany, what spending there is, is directed by Davies (acting as the customer). As contractor he runs a number of establishements, of which the most important is the NPL.

For a further example of his philosophy, Davies talked to me at some length about batteries. He showed me with glee a publication from Washington, D.C., *The Energy Daily*, dated June 29, 1979, in which he was quoted as having said that Americans, if there is a period of gas shortage or rationing, may rush to buy electric automobiles because they are "very affluent, very passionate and very prehensile." This purchasing could greatly help electric vehicle development. He sees a significant place for the electric-powered delivery vehicle, and as a result the Department of Industry is providing some partnership money for firms working on it. It uses no more and no less energy than other types of vehicles, but it does spread the types of fuel since the electricity can be based on uranium, coal, or hydro power. Its capital cost is high, but this may come down appreciably with economies of scale. Battery-driven delivery vehicles are ideal for urban delivery purposes. Those driven by lead-acid (conventional) batteries can only go 50-70 miles per day; but this is more than the average urban van mileage. Later, lead-acid may be replaced by lighter-weight batteries—for example, sodium-sulphur batteries, which could extend the performance to 150-200 miles per day and make other types of electric vehicle marketable. But there are problems: the lead-acid batteries can be deep discharged and cycled many times, and they can survive a failure of one cell of a multicell battery. These things are not yet true of higher-performance batteries. For this reason the Department of Industry is sponsoring work on both battery systems. Sometime after the 1980s the sodium-sulphur or nickel-zinc battery may become economic on the production scale and supplement the lead-acid battery, which will however retain a market for some duties into the 2000s. Beyond 2000 fuel cells are definitely coming, and will represent a significant increase in efficiency. The system will utilize batteries for peak loads, with a single engine operating off both the fuel cell and the battery. These are not opinions with which many people concur, but Davies is nonetheless confident of them.

I asked him how he reaches his conclusions; specifically, what sort of systems studies does he do? Do they use simulations, computers, and sophisticated mathematical modeling techniques? The answer to all these questions is "no." He has a small policy unit that consists mostly of physical scientists rather than those trained in systems analysis. He also uses bright outside people; he has, for example, contracted some studies to the Center for Policy Alternatives at M.I.T. (Cambridge, MA). He told me that British technical civil servants have a long tradition of "being on tap, but not on top"; that is, one keeps them available for consultation, but does not let them make decisions. He wants them on top, playing a full part in policy. Systems analysis is a new thought in the Department of Industry, he told me, and it must be introduced slowly. "Economic models are ephemeral and must be used quickly," said Davies, and so what jobs they do are based on quick little models. (Robert E. Machol)

ULTRASONICS

ULTRASONICS INTERNATIONAL 79

Ultrasonics International 79, the 12th conference in the Ultrasonics International series, differed from the IEEE-sponsored Ultrasonic Symposia in the US in the following ways: (1) The conference was sponsored by a private-enterprise organization, the journal *Ultrasonics*, published by IPC Science and Technology Press, Ltd., Guildford, Surrey, UK; (2) Whereas about half of the recent IEEE Ultrasonics Symposia were devoted to problems dealing with surface acoustic waves, I found only two papers concerned with that subject in Ultrasonics International 79; (3) In addition to being a source of information by way of technical papers, the conference was also a miniature trade show.

According to the brochure, the preceding 11 conferences in the series had been held in the UK; this one differed. It was held in the very picturesque city of Graz, the second largest city in Austria, located very near to both Hungary and Yugoslavia. The entire conference was in Graz's Conference Center, a beautiful concert hall completed in 1908, which, according to the inscriptions, was the 60th year of the reign of Emperor Franz Josef I. Both the technical sessions and commercial exhibits, therefore, were located in a beautiful latter-day baroque environment. Moreover, we were surrounded by pictures of Beethoven, Gluck, Mendelssohn, Schumann, and others—an atmosphere that certainly provided a bit of warmth not usually found in technical meetings.

The conference organizer was Dr. Zdenek Novak, Managing Editor of *Ultrasonics*, which advertises itself as the world's only journal devoted entirely to the properties, effects, and applications of ultrasound.

The local organizer of the conference was Dr. B. Langenecker, who presently heads PVL (Physikalische Versuchsanstalt), a small consulting and manufacturing firm in Waldbach, Austria. Dr. Langenecker has many friends in the US; he was formerly Head of the Metal Physics Branch of Michelson Laboratory of the Naval Weapons Center, China Lake, CA. He is also known as the individual who, with F. Blaha, discovered elongation of metal under ultrasonic action, in 1955.

The conference had 4 invited papers, additional technical sessions with around 80 papers that covered a number of different areas of ultrasonics, and poster sessions of 40 more papers that allowed direct discussion with the authors.

In the following I give brief summaries of the invited papers, list the topics and some examples of the contributed papers, provide a sampling of what was seen in the poster sessions, and conclude with a listing of some of the European exhibitors and their products.

Invited Papers

(1) "Ultrasonics in Industry," by S. E. Jacke (Smith-Kline Ultrasonics Products, Danbury CT, USA), discussed how power ultrasonics is being utilized in industry. The best-known application here is cleaning—from the cleaning of hard surfaces to carpet cleaning. Other applications are ultrasonic welding of thermoplastics, metal welding, machining of hard materials, wire drawing, tube drawing (for odd as well as regular shapes), organic cell disruption (in drug manufacturing), fuel emulsion forming (for cleaner burning), waste water treatment, and ultrasonic agitation of electrolytes for storage batteries. All except the last of these are well established. Jacke mentioned that there have been no new scientific advances in industrial ultrasonics in the past 10 years.

(2) Roy S. Sharpe, the Head of the Nondestructive Testing (NDT) Unit at AERE, Harwell, UK, one of the largest groups for NDT in the world, in "Putting a Perspective to Ultrasonics NDT Research," complained that "no one is falling over himself for the fruits of the labor of NDT researchers." He stated that actually progress in NDT has been slow because of minimum theoretical input and lack of interest on the part of industry. He cited the limitations of first-generation NDT as: (a) basically qualitative techniques; (b) the reliability is suspect; (c) demand for high skills of operating personnel; (d) insufficient scientific backing; (e) not consistent with modern signal processing techniques. Sharpe stated that second-generation NDT would require automatic defect interpretation and that research should be performed on transducers, instrumentation and microprocessors, wave modes and interaction, and data interpretation.

(3) W. Lauterborn (Universität Göttingen, FRG) in "Cavitation, Bubble Dynamics," gave a brief account of different kinds of cavitation (hydraulic, acoustic, optic). He described experiments in acoustic cavitation which were conducted to reveal the basic features of the motion of the cavities produced. This included the use of high-speed photography (up to 200,000 frames/sec) and holography (up to 20,000 holograms/sec). He also stated that his group has treated the problem of acoustic cavitation noise by performing numerical calculations of the response of single bubbles in a sound field and arriving at noise spectra similar to those measured.

(4) S. Schuy (Technische Universität, Graz, Austria) in "Ultrasound in Medicine: Present Status and Future Aspects," reviewed some of the successes of ultrasonics using pulse echo techniques. Present efforts, he stated, deal with quantitative investigations of the manifold ultrasound-tissue interactions. Using such additional

information, the second generation of ultrasonic devices and development can now be expected to permit improved localization as well as tissue differentiation and quantitative ultrasonic diagnosis. He stressed that the development of microprocessor systems is now leading to improved handling, comfort, and accuracy of the apparatus.

Titles of the sessions of contributed papers and some examples are listed below:

(1) Physics of Ultrasound and Ultrasonics: Papers ranged from "Effect of Thermal Cycling under Microstructure of the β Cu-Al Martensite, a Study by Acoustic Emission and Electron Microscopy" by E. Esmail, I. Grabec, and V. Krasavec, (Univ. of Ljubljana, Yugoslavia), who showed how acoustic emission (AE) can be used to predict changes in the microstructure of martensite, to "Saw Single-Spike Pulse Transducer," by G. Tobolka, H. Reichard and F. Seifert, (Institut für Physikalische Elektronik der Technischen Universität Wien, Vienna, Austria). Single-spike pulses of high intensity were obtained with a 21-period interdigital array by feeding successive fingers from different taps of a delay device rather than from a bus bar.

(2) High-power Metallurgical: Four papers dealt with the use of ultrasonics for wire drawing, a new method of quality control for ultrasonic wire bonding, and ultrasonic welding of electrical contacts.

(3) Instrumentation: An interesting example of this work was a presentation by B.B. Djordjevic and R.E. Green, Jr. (The Johns Hopkins Univ., Baltimore, MD). According to this paper, there is ever-increasing evidence that the high-frequency components contained in the initial portion of AE transients represent the true signal characteristics of the acoustic emission mode. To capture this information, the authors let the waves initiated by a propagating crack pass into a transparent material for which an optical detecting system could give fast frequency response.

(4) Nondestructive Testing: There were more papers related to this topic than to any other. Various instruments and schemes were described, including inspection of thin-walled tubes, concrete piles, and strips and plates. There was also an interesting paper by V.L. Newhouse, E.S. Ferguson, N.M. Bilgutay, and J. Saniie (Purdue Univ., W. Lafayette, IN) in which the visibility of flaw echoes with respect to grain echoes of a material was enhanced by signal processing techniques.

(5) Ultrasonic Processing: A paper by I. Gavrila (Universitatea din Brasov, Romania) was concerned with life prolongation of batteries subjected to ultrasound. The abstract stated that there were performance improvements over untreated batteries at low temperatures, but the actual paper was not presented. Other subjects in this section dealt with compacting of pressed powders, comminution of brittle materials and some historical highlights of ultrasonics.

(6) High-power Ultrasonics: In addition to papers dealing with cavitation erosion, ultrasonically aided hot-pressing of powder materials, and changes of ultrasonic attenuation and velocity because of high power insonation of metals, there was a paper by K. Seya, T. Otsuka (Nihon Univ., Narashino, Chiba 275, Japan) and M. Domenick, M. Haider, and H.V. Fairbanks (W.VA Univ., Morgantown, WV) which summarized results indicating that ultrasound can increase the thermal conductivity of metal.

(7) Medical and Biological Applications: J. McCaffrey (Univ. of Queensland, Australia), a surgeon, questioned in his talk whether ultrasound could replace arteriograms. Specifically, he suggested the velocity profiling of blood flow. He listed requirements for an ultrasound medical imaging device as one whose quality is as good as x-rays or better, has a resolution of at least 1 mm, is electronically and physically stable and reasonably mobile, can velocity-profile blood flow in as close to real time as possible, and is computer compatible. In addition to this paper there were a number of other papers related to specific medical and biological applications.

(8) Ultrasonic Sensing and Visualization: Topics in this session included such subjects as "The Visualization of Ultrasonic Waves in Liquids by Stroboscopic Photoelasticity," by J.A. Archer-Hall and D.A. Hutchins, (Univ. of Aston, Birmingham, UK), a paper describing the use of ultrasonics for archeological detection, as well as a presentation by P.A. Lewin (Inst. of Biomedical Engineering, Copenhagen, Denmark, and F. Jensen, Hillerød Hospital, Hillerød, Denmark), which reported the development of miniature sensing transducers that may be used in conjunction with a hypodermic

needle guided by B-scan visualization, to measure the acoustic pressure at a preselected point in a medium.

(9) Underwater Ultrasonics: Several papers dealt with detecting and imaging objects underwater. An example is the "The Detection of Cracks in Underwater Steel Structures Using an Ultrasonic Camera System," by G.W. Vernon and P.H. Brown, (EMI Central Res. Laboratories, Hayes, UK), which described an ultrasound TV camera system based on the electron-beam-scan scanned-image-converter principle to provide real-time images of submerged objects, using either reflected or transmitted radiation.

(10) Transducers: This session contained 3 papers which dealt with diffraction effects found with wide-band transducers, near-field beam patterns of line-focused ultrasonic probes, and the development of transducers based on the use of polyvinylidene fluoride.

A number of interesting papers were also found among the 40-odd papers in the poster session. I list only two of these: "Acoustic Emission of Cracking Dental Filling," by D. Groselj, P. Muzic, I. Grabec, C. Ravnik (Univ. of Ljubljana, Yugoslavia), and "Effect of Removing Smoke by Electrostatic Precipitator with High-Intensity Ultrasound Field," by K. Seya, T. Nakane, and T. Otsuka (Nikon Univ., Japan).

Finally, since an important aspect of the conference was the miniature trade show, and since it may be desirable to some readers to learn the names of European companies, I compiled a list of some of the firms represented and of their products. I shall be happy to send a copy of this list to interested individuals upon request.

The Proceedings of Ultrasonics International 79 have been published and are available from Ultrasonics, PO Box 63, Westbury House, Bury St., Guildford, Surrey GU2 5BH, UK, at a price of £22.50. (Irving Kaufman)

NEWS & NOTES

Five-Year Freeze on Space Research in UK

There will be no new British Space program before 1985 and money for several other major projects—including research into biotechnology and earth resources—is to be severely limited in the next few years.

This decision, contained in the Science Research Council's (SRC) plan for 1981-1985, was approved by the council last week. However, some important new projects are to be funded, despite recent cuts by the UK Government in the science budget. These include the £9 million optical telescope and the £5.7 million millimeter radiation instrument for the Northern Hemisphere Observatory in the Canary Islands; a £2.3 million investment in robotics research; and a commitment to participate in the European large electron-positron (LEP) collider to be built near Geneva, Switzerland.

In its submission to the Advisory Board Research Council, SRC outlines its priorities for funding, given that it is to receive support which will now remain relatively constant at about £165 million in 1979 prices. These are spread over the SRC's four boards—engineering, astronomy, space and radio, science and nuclear physics.

The major commitment for engineering will center on the implementation of the Roberts' report, published in March 1979, which called for a substantial SRC role in preparing Britain for the advent of the microprocessor. This will be done by setting up microelectronics programs in schools, universities, and at postgraduate and continuing education levels, and by establishing several large new research programs.

Dr. D. Worsnip, who is in charge of the scheme, said a major portion of the programs' £9 million cost would be spent on robotics research which would concentrate on new techniques to be used in industrial automation. This would cost £2.3 million and a further £1.4 million would be spent on new MSc courses in integrated circuit design; £800,000 on research into microelectronic sensor and measuring techniques; and £900,000 to set up a large-scale integration microchip plant at either Edinburgh or Southampton University.

Within engineering, some economies have been made by dropping research projects in medical and civil engineering and in marine technology. The council's commitment to biotechnology is limited to £2.75 million over the four years, although the SRC would like to spend much more.

In astronomy, space and radio, priority is to be given to the construction of the £4.2 million optical telescope for the Canaries. This was originally to have cost £16 million but a drastic cost-cutting exercise by astronomers—which will leave the observatory without instrument-preparation rooms, libraries, and rest accomodations—has successfully ensured the go-ahead for the project. A £5.7 million instrument to measure radiation on wavelengths between radio and light will also be built.

Research grants will suffer as a result of the economies, although the council hopes to complete its synchroton radiation source project at Daresbury this year. The spallation neutron source facility, projected for construction at the Rutherford Laboratory, will not be built until 1984 or 1985—which may cause an escalation in costs and leave the machine out of date.

University research grants in high-energy physics will be cut to afford proper funding of the LEP project, although this may leave departments with insufficient resources to make use of the European machine when it is built. A further £250,000 is to be saved by closing the Glasgow University accelerator and limiting funds for the one at Oxford University.

Center to Link Science and Industry

A venture to bring academic research and the needs of industry and government closer together is being launched by the Leverhulme Foundation, the Science Research Council and the Social Science Research Council. An enterprise has been founded and has been given the acronym CATCH, standing for Centre for Analysis of Technical Change.

The site of the center, involving scientists, engineers, economists, and lawyers, is under discussion with the Department of Education and Science, because the choice will be on a university or polytechnic campus.

One of the motives behind the project arises from concern that the brilliant record in academic research in Britain is not reflected in prosperous science-based industries. There is a general acceptance that science and technology are significant social and economic factors in society.

No one in the UK or anywhere else has determined what correlation exists between economic growth on the one hand and the employment of professional scientists and engineers in research and development on the other.

Only in general terms are there indications that discoveries of new drugs, chemicals, computers and microprocessors are based on a mating of scientific knowledge with industry.

The need to improve understanding was apparent to the Science Research Council in deciding over the past two years how much support to give to new topics, such as microbiology and genetic engineering, on which the new biotechnology industries will be based.

An increase in support for biotechnology by the council, under which academic research programs are assessed equally on scientific excellence and industrial potential for the first time, has been applauded by the UK Government's scientific advisors.

The biotechnology industries offer a new method of manufacturing pharmaceuticals, fine chemicals, and animal feedstuffs, and of recycling industrial waste and controlling pollution.

Science-based companies such as Cetus and Genenech in the United States, and Biogen, in Switzerland, have been formed to develop those processes. Within three to four years, the results of their work will be coming onto the market.

Yet in that field, the UK Government's Advisory Council for Applied Research Development finds that cooperation between British universities and industry seems particularly poor, and traditional attitudes of indifference or distrust are prevalent on both sides.

The council also criticizes the ignorance of most academic scientists about the complexities of patenting, industrial markets, profitability and cash-flow difficulties. That ignorance limits the immediate usefulness of academic research groups to industry.

That is why the new CATCH enterprise will embrace lawyers and economists with scientists and technologists in finding the best way to provide the underpinning essential for British industry.

The inquiry into biotechnology by the Advisory Council also finds that many research workers would be happy to devote part of their time to applied problems, but they seldom know what those are.

British industry lags behind that of most other countries in the extent to which it used academic consultants. The government advisors express regret at evidence that such consultancies are used by overseas firms which can take advantage of the discoveries of UK scientists.

PERSONAL

Sir Arnold Hall, chairman of the Hawker Siddeley Group since 1967, has been elected chancellor of the Loughborough University of Technology in succession to Lord Pilkington, who is resigning after 14 years.

Professor John Horlock has been appointed vice-chancellor of the Open University. He succeeds Lord Perry, the university's first vice-chancellor. Prof. Horlock has been vice-chancellor of Salford University.

Dr. Paul Broda has been appointed the first professor of molecular biology at the University of Manchester Institute of Science and Technology. He is at present lecturer in molecular biology and member of the molecular genetics unit in the University of Edinburgh.

OBITUARIES

Prof. Sir Edward Bullard, who had been director of the National Physical Laboratory and professor of geophysics at the University of Cambridge, died on 3 April. He was 72.

Dr. Ulick R. Evans, emeritus reader in the science of metallic corrosion at the University of Cambridge, died on 3 April at the age of 91.

Sir Charles Goodeve, died on 7 April at the age of 76. An authority on science as applied to industry, in particular metals and chemistry, he was a former president of the British Iron and Steel Research Association. He also served as a vice-president of the Royal Society from 1968 to 1970.

Mr. H. Daintree Johnson, who was one of the best-known gastroenterological surgeons in the London School of Medicine, died on 2 April. He was 69.

Dr. John A. Saxton, director of the Appleton Laboratory from 1966 to 1967, died on 17 April at the age of 65. He had an international reputation for his expertise in the field of radiometerology.

ONR Cosponsored Conferences

6th European Specialist Workshop on Microwave Active Semiconductor Devices, Bad Durkheim, W. Germany, 7-9 May 1980.

Euroepan Workshop in Leadership and Managerial Behaviour, Univ. of Aston, Birmingham, England, 15-16 May 1980.

Conference on Analytical and Numerical Approaches to Asymptotic Problems, Nijmegen, Netherlands, 9-13 June 1980.

Phase Transitions and Applications of Ferroelectric and Related Materials, Ettore Majorana, Erice, Italy, 1-15 July 1980.

VIII IUPAC Symposium on Photochemistry, Seefeld, Austria, 13-19 July 1980.

NATO Advanced Study Institute, "Statistical Distribution in Scientific Work," University of Trieste, Trieste, Italy, 14-25 July 1980.

VI International Conference on Atmospheric Electricity, Manchester, England, 28 July-1 August 1980.

NATO Advanced Study Institute, "New Concepts in Multi-User Communications," University of East Anglia, Norwich, England, 4-16 August 1980.

"Physics of Transition Metals" Conference, The University of Leeds, England, 18-22 August 1980.

International Conference on Physics in One Dimension, Fribourg, Switzerland, 25-29 August 1980.

International Conference on Adhesion and Adhesives, Durham, England, 3-5 September 1980.

Conference on Physics of Dielectric Solids, University of Kent, Canterbury, England, 8-11 September 1980.

3rd International Symposium on Gas Flow and Chemical Lasers, Marseille. France, 8-12 September 1980.

International Symposium on Gallium Arsenide and Related Compounds, Vienna, Austria, 22-24 September 1980.

European Visitors to the US, Supported by ONR London

Name of Visitor	Affiliation	Navy Lab./Org. to be Visited
	MAY	
Almoster Ferreira, Prof. M.A.	Chemistry Dept., Univ. Lisbon, Portugal	NRL, NSWC, DTNSRDC
Harris, Dr. F.M.	Royal Research Unit, Univ. College of Swansea, UK	NRL, ONR, DTNSRDC, NSWC
Zimmerman, Prof. H.J.	RWTH Aachen, W. Germany	NRL, ONR
Dunbar, Mr. Robin & Holmes, Mr. Robin	Dept. of Electrical & Electronic Eng., Heriot-Watt Univ., Edinburgh, UK	NOSC, NRL
	JUNE	
Van Welzenis, Dr, R.G.	Technische Hogeschool, Eindhoven, Netherlands	NRL, NOSC NPG School
Ingram, Dr. Malcolm	Dept. of Chemistry, Univ. of Aberdeen, UK	NRL, NSWC
Zaghoul, Dr. A.-R.M.	Electrical Eng. Dept., Faculty of Eng., Cairo Univ., Egypt	NWC
	JULY	
Pidgeon, Dr. Carl R.	Dept. of Physics, Heriot-Watt Univ., Edinburgh, UK	NRL, NSWC
Dearnaley Dr. G.	Nuclear Physics Div., AERE Harwell, UK	NRL
Walls, Dr. J.M.	Dept. of Physics, Univ. of Technology, Loughborough, UK	NRL, NSWC
	AUGUST	
Meares, Prof. Patrick	Dept. of Chemistry, Univ. Aberdeen, UK	NRL
El-Sherbiny, Prof. M.G.D.	Faculty of Engineering, Cairo Univ., Egypt	NRL, ONR, DTNSRDC, NSWC
Cornbleet, Dr. Sidney	Univ. of Surrey, Guildford, UK	NOSC, NPG School
	SEPTEMBER	
Parker, Dr. A.P.	Royal Military College of Science, Shrivenham, UK	NRL, DTNSRDC, NSWC
Price, Dr. Dennis	Dept. of Chemistry & Applied Chemistry, Univ. Salford, UK	NRL, DTNSRDC, NSWC